



## **ACUMEN DELIVERABLE 5.4c Cluster analysis of bibliometric indicators of individual scientific performance**

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Cluster analysis of bibliometric indicators of individual scientific performance  
ACUMEN Deliverable 5.4c

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## 1 Introduction

As discussed in Wildgaard, Schneider and Larsen (2014) bibliometricians are cautious of evaluation at the level of individuals, as the context and variables affecting the results of analyses are many, and often unsatisfactorily explored. Hence, the debate on the shortcomings of performance indicators generated by bibliometric methods at the micro-level continues (Bach, 2011; Bornmann & Werner, 2012; Burnhill & Tubby Hille, 1994; Sandström & Sandström, 2009; Wagner et al., 2011). Despite of the concerns from the bibliometric community, evaluation of the individual through bibliometric indices is already being performed as a form of ‘pseudo peer review’ in selection of candidates for tenure, in background checks of potential employees’ publication- and citation impact, and in appraisal of funding applications. As part of developing the ACUMEN portfolio we therefore carried out an extensive review of 114 bibliometric indicators in WP5 Deliverable 5.1 to identify 1) which indices are useful in individual self-evaluation to document activities listed on the CV and contextualize publication performance, 2) identify which scientific activities it is possible to measure and with which indices, 3) analyse the applicability of these indices by discussing the strengths and weakness of each one, and 4) identify if there is a need for any additional novel indicators to measure the performance of individuals.

The analysis showed that there is no immediate need to develop new bibliometric indicators. There is a wealth of indicators to choose from, some used in practice and some theoretical only. There is therefore a need to understand the usefulness of existing indicators and which ones represent independent research activities of authors. In this paper, we investigate how 1) traditional and novel indicators complement each other, 2) if there is a redundancy among indicators, i.e. two or more indicators measure the same thing, and 3) which indicators are the “best” choice in regards to our four predefined disciplines. The main parameter we judge the usefulness of indicators on is their simplicity, as investigated in Wildgaard, Schneider and Larsen (2014) and their sensitivity to publishing and citation traditions within disciplines.

## 2 Data

The analysis in this paper is based on citation and publication data of European researchers. The data is drawn from the shared ACUMEN data set of 2,554 researchers in four scientific disciplines who responded to an online survey of web-presence conducted by WP2. In the analysis in the present paper the researchers to have 1) an active curriculum vitae on the web, and 2) a publication list on the web. A subset of 741 researchers from the shared ACUMEN data set fulfilled both conditions<sup>1</sup>.

In the survey the respondents reported their academic discipline and seniority, and these are used to group the 741 researchers analysed in this paper. We extracted their publications from the CVs and searched the Thomsen Reuters Web of Science (WoS) to identify these publications. We identified 34,660 citable papers indexed in WoS, written by 741 European researchers in the disciplines of *Astronomy, Environmental Science, Philosophy and Public Health*. Additional publication and citation information on articles and reviews in this data set was kindly provided for the purposes of this study by the Centre for Science and Technology Studies (CWTS) at Leiden University, the Netherlands from their custom version of the WoS. This custom database contains records from the Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index portions of WoS, and has been specially prepared for bibliometric analysis. The data delivered by CWTS thus contains a wide range of bibliometric indicators for each paper including field

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<sup>1</sup> Please refer to the following WP5 deliverables 5.1 “Literature Review” and 5.3 “selection of samples”.

normalised indicators using CWTS standard procedures. As the CWTS data does not contain data from the Conference Proceedings Citation Indexes we do not have additional data on 3,693 citable papers and these are excluded from the present analysis. Our final data set thus consists of 30,967 publications with additional citation information.

**Table 1. Sample of 741 researchers, distribution of publications and citations across disciplines and seniorities.**

Publications					Citations		
Discipline	Sample	Range	Median (CI)	Mean (CI)	Range	Median	Mean (CI)
<b>Astrology, 192 researchers</b>							
<i>PhD</i>	15	2-36	7(5.0;14.2)	10.8(5.6;15.9)	8-529	150(27.9;209.7)	149.4 (64;234.7)
<i>Post Doc</i>	48	3-103	19.5(14;26.5)	26 (19.9;32.1)	3-3177	201.5(140.4;479.4)	561.1(339.7;782.4)
<i>Assis Prof</i>	26	10-142	39.5(30;65.9)	51 (37.3;64.8)	69-4009	702 (432.2;1327.5)	1118.6 (675;1562.1)
<i>Assoc Prof</i>	66	7-292	61.5(48.5;75.4)	77.7(63.2;92.2)	19-9083	1214(783.6;1622.8)	1981.1(1477.8;2484.4)
<i>Professor</i>	37	34-327	90(75.2;109.6)	121.3(92.8;149.8)	177-16481	1889(1292.9;3245.3)	3579.1(2170.9;4988.2)
<b>Environmental Science, 195 researchers</b>							
<i>PhD,</i>	3	3-5	4	4	16-60	34	36
<i>Post Doc</i>	17	2-59	9(6;12.9)	12.8(5.6;20)	10-642	41(25;56)	91.7(11.1;172.2)
<i>Assis Prof</i>	39	2-46	18(13.9;20)	19(15.6;22.5)	0-573	148(90.6;167.6)	185.4(133.7;237.1)
<i>Assoc Prof</i>	85	1-103	29(25;41)	36.8(31.7;42)	2-2519	326(232.9;459.4)	520.1(404.4;635.7)
<i>Professor</i>	51	1-425	51.5(39.3;64.2)	59.7(46.8;72.5)	6-14141	435(324.5;722.6)	998.1(614.7;1381.5)
<b>Philosophy, 222 researchers</b>							
<i>PhD</i>	8	1-5	1(1;4.1)	2(0.6;3.3)	1-33	0.5(0;13.5)	6.2(-3.2;15.7)
<i>Post Doc</i>	22	1-31	4(3;8)	7(3.8;10.1)	0-235	8(1-10)	21.4(-1.9;44.7)
<i>Assis Prof</i>	44	1-106	6.5(4;8.9)	10.8(5.7;15.9)	0-1829	6.5(3;20)	74.3(-11.5;160.2)
<i>Assoc Prof</i>	73	1-45	7(6;9)	10(7.8;12.1)	0-565	8(5;13)	50.7(22.7;78.7)
<i>Professor</i>	75	1-140	18(13.5;23.4)	28.1(21;35.2)	0-3495	29(20.5;65.6)	157(52.1;262)
<b>Public Health, 132 researchers</b>							
<i>PhD</i>	9	4-27	8(7.1;17.8)	12.2(6.6;17.8)	7-253	60(34.5;146.7)	82.2(23.5;140.8)
<i>Post Doc</i>	14	1-23	11(8.8;14.4)	12(8.6;15.3)	0-353	80.5(21.5;203.9)	113.6(49.4;177.6)
<i>Assis Prof</i>	30	3-288	22(13.1;29.6)	36.2(15.6;56.7)	10-3796	167(107.8;350.8)	417.4(131.4;703.3)
<i>Assoc Prof</i>	50	4-221	43(30.6;56.3)	54.6(41.6;67.7)	4-3649	518(312.6;701.7)	778.5(539.4;1017.5)
<i>Professor</i>	29	5-661	76(53.6;107.6)	110.2(62.7;157.7)	13-13520	954(554.2;2394.7)	2104(1065.3;3142.6)

Table 1 provides an overview of the data set used in this study showing publication and citation data distributions across the four disciplines and the academic seniorities of the 741 researchers in the sample. The four disciplines are very broad and comparison of scientists within each discipline and across sub disciplines is not recommended in practice as publication and citation behaviour differ greatly. However in this quantitative study, trends of indicator performance on a disciplinary level are identifiable. Preliminary data exploration shows that *Astronomy* has a strong preference for multi-authorship and article publication; *Environmental Science* publishes a great amount of conference papers and are only partially represented in Web of Science; *Philosophy* is a dialogue-based discipline, preferring single authorship and publishing in blogs, books and in national languages whereas *Public Health* has a strong tradition of publishing articles in international journals indexed in the citation databases, but also publishes a fair amount of articles in local journals in national languages as issues often concern local health issues and regulations. Only *Public Health* researchers exhibit regular publication trends that can be captured by average measures at the seniority level; the other three disciplines suggest highly individual production rates where averages rates do not match well with seniority level.

### 3 Methods

As reported in Wildgaard, Schneider and Larsen (2014), the usability of indices is a major consideration therefore the complexity of each indicator was assessed. The indices were graded on a 5 point numerical scale to assess 1) the availability of citation data and, 2) the intricacy of the mathematical model required to compile the indicator. This assessment might result in a reduction of the granularity and sophistication of the indices we identify as useful, and might even encourage the use of rougher measures over more accurate ones. The indices have to measure what they purport to measure, however, usability is lost if correct measurement requires data that is not readily available to the researcher, difficult mathematical calculations, and intricate interpretations of complicated data output. We assume the user of the indicators has a complete publication list and would only need to find citations and calculate the indicator. Only indicators that we scored  $\leq 3$  (on a scale where 5 was highest complexity / data collection required) were considered for the analysis. Simplicity is an important criterion for researcher-level indicators because it is more often than not librarians, information specialists, administrators or even researcher's themselves that use them to compare and discriminate between scholars in an evaluation. This results in 37 potentially useful indicators at the individual level that are analysed in this paper. These indicators are supplemented by 17 field level performance indicators supplied by CWTS. For an overview see Table 4 where the indicators are briefly presented along with information of the data they have been derived from and the various factors that are applied in their calculation. For details on their calculation please refer to Appendix 2 as well as Wildgaard, Schneider and Larsen (2014).

The set of selected indicators is intended to capture the major output and effects of a researcher's published work that can be captured using publication and citation data. Figure 1 provides a systematic overview of the indicators and the relations between them. Indicators in *blue* pertain to publication output, and counts publications in various ways. Indicators in *green* measure the effect of output and are based on raw citation count such as **C** or fractionalised citation counts, as well as average citations of the entire portfolio, for example **CPP**. Indicators in *red* measure impact over time, e.g. with citations adjusted for length of academic career such as **AW**, and are often adjusted to field norms such as **IQP**. Indicators in *purple* measure citations to core or selected publications, e.g. **H**. All these indicators are simple to calculate but in prioritizing simplicity our method may resulted in choosing coarse measures of performance. Therefore, we compare these relatively simple indicators to the more sophisticated indicators of expected performance that are CWTS field standards, indicated in *yellow* such as **pp top prop**, **mnjs**, etc.

#### 3.1 Data analysis

The primary purpose of this report is to analyse and compare different bibliometric indicators using the citation and publication records of individual scientists. We wish to investigate if the simple or sophisticated indicators discriminate just as well between the scientists of different academic seniorities and disciplines. From this point of view, the best choice of indicators will be dependent discipline, academic seniority and complexity. We will address the recommendation of indicators using standard statistical methods.

For each discipline we also computed a correlation matrix for the indicators using Kendall's tau rank correlation coefficient, which is a standard correlation measure for non-parametric data. Kendall's tau is a non-parametric test that measures the correlation of the ranks of the samples instead of the actual values. This means it bases the correlation on the extent pairs of variables agree, and is effective for smaller sample sizes and is insensitive to errors. Perfect agreement  $\tau=1$ , independence  $\tau=0$  and

increasing values between -1 and 1=increasing agreement between the variables. We used IBM SPSS version 19 for the statistics.

### 3.2 Limitations of the analyses

The exclusion of the 3,693 records that were mainly in conference proceedings had a great effect on the *Astronomy* sample; see Table 2 and Table 3. Some researchers lost up to 80% of their publications. Appendix 1 presents a detailed overview. Basic citation data on these publications can be identified in WoS and it will be possible to calculate a selection of the indicators in Table 2 for these publications. This is, however, beyond the scope of this paper and we leave this for future work.

Our experience with the missing data, illustrates how important it is in a bibliometric evaluation to report the version of the citation index the data is collected from, e.g. version of WoS. In our case, the publication and citation analysis in the present study is limited to articles and reviews and is based on information indexed in the version of WoS data that we use. Such information must be reported in an evaluation report to enable third parties to understand what is included and is not included in the evaluation.

**Table 2. Effect of removing papers on a disciplinary level.**

	<b>N with publication and citation information</b>	<b>N without publication and citation information</b>	<b>Total</b>	<b>%</b>
<i>Astronomy</i>	12,359	2,467	14,826	16,6
<i>Environment</i>	7,820	863	8,683	9,9
<i>Philosophy</i>	3,494	264	3,758	7
<i>Public Health</i>	7,294	99	7,393	1,3
<b>total</b>	<b>30,967</b>	<b>3,693</b>	<b>34,660</b>	

**Table 3. Percent missing publications by level of seniority.**

	<b>PhD</b>	<b>Post Doc</b>	<b>Assistant Prof.</b>	<b>Associate Prof.</b>	<b>Professor</b>
<i>Astronomy</i>	12,4	13	13,9	16,6	18,4
<i>Environmental</i>	7,6	20,1	7	6,9	12,2
<i>Philosophy</i>	0	6,6	7,3	3,3	8,2
<i>Public Health</i>	0	0	0,9	0,9	1,9

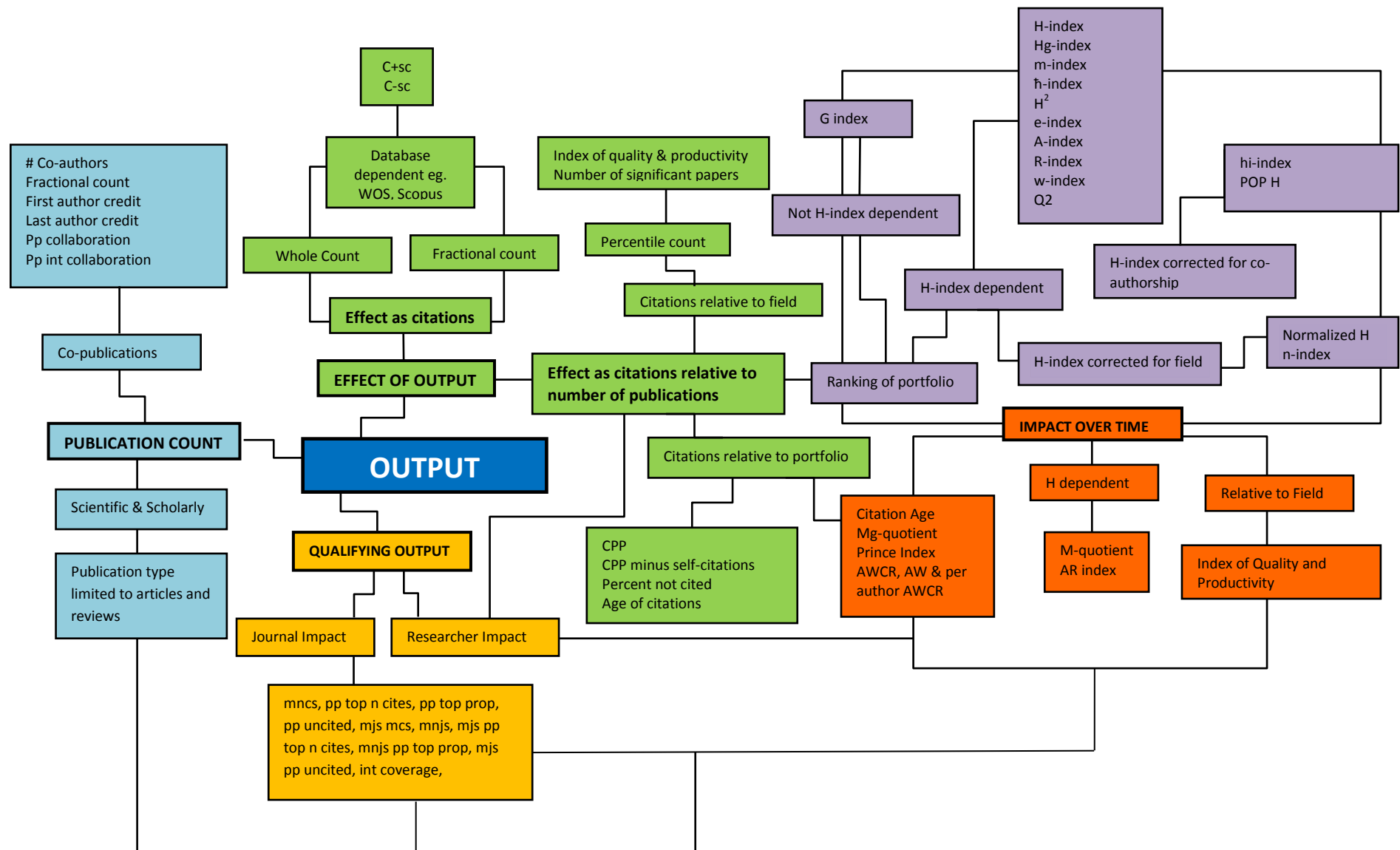


Table 4. Indicators of individual impact as well as discipline benchmarks analysed in this study.

ID	Type	Abbr.	Indicator	Intention
<b>Productivity metrics</b>				
1	Publication	P	Publication count	Total count of production used in formal communication. Limited in our dataset to ISI processed publications
2	Publication	Fp	Fractionalized publication count	Each of the authors receive a score equal to 1/n to give less weight to collaborative works
3	Publication	App	Average papers per author	Indicates average amount of collaboration per paper
4	Publication/time	Pyrs	Years since first publication	Length of publication career from 1 <sup>st</sup> article in dataset to 2013
<b>Impact metrics</b>				
5	Citation	C	Citation count	Use of all publications
6	Citation	C-sc	Citation count minus self-citations.	Use of publications, minus self-use.
7	Citation	Sig	Highest cited paper	Most significant paper
8	Citation	minC	Minimum citations	Minimum number of citations
9	Citation	%sc	Percent self-citations	Disambiguate self-citations from external citations
10	Citation/author	Fc	Fractional citation count	Remove dependence of co-authorship, all authors receive equal share of citations.
11	Citation/time	C<5	Citations less than 5 years old	Age of citations
<b>Hybrid metrics</b>				
12	Citation/publication/field	IQP	Index of Quality & Productivity	Number of citations a scholar's work would receive if it is of average quality in the field
13	Citation/publication/field	Tc>a	(part of IQP)	Actual times scholar's core papers are cited more than average quality of field
14	Citation/publication/field	H norm	Normalized h	Normalizes h-index (to compare scientists across fields).
15	Citation/publication	Cage	Age of citation	If citations are due to recent or past articles
16	Citation/publication	%PNC	Percent not cited	If citations are due to a few or many articles
17	Citation/publication	CPP	Citations per paper	Average citations per paper
18	Citation/publication	h	h index	Cumulative achievement
19	Citation/publication	g	g index	Distinction between and order of scientists
20	Citation/publication	m	m index	Median citations to publications included in h to reduce impact of highly cited papers
21	Citation/publication	e	e index	Supplements h, by calculating impact of articles with excess h citations
22	Citation/publication	w	wu index	Impact of researcher's most excellent papers
23	Citation/publication	hg	Hg index	Balanced view of production by keeping advantages of h and g, and minimizing their disadvantages
24	Citation/publication	H <sup>2</sup>	Kosmulski index	Weights most productive papers
25	Citation/publication	A	A index	Magnitude of researcher's citations to publications
26	Citation/publication	R	R index	Improvement of A-index
27	Citation/publication	AR	AR-index	Citation intensity and age of articles in the h core
28	Citation/publication	h	Miller's h	Overall structure of citations to papers
29	Citation/publication	Q <sup>2</sup>	Quantitative & Quality index	Relates the number of papers and their impact
30	Citation/publication/author	hi	individual h	Number of papers with at least h citations if researcher had worked alone

<b>ID</b>	Citation/publication/author	<b>POP h</b>	Harzing's publish or perish h index	Accounts for co-authorship effects
<b>31</b>	Citation/publication/author/time	<b>AWCR</b>	age weighted citation rate	Number of citations to all publications adjusted for age of each paper
<b>32</b>	Citation/publication/author/time	<b>AW</b>	Age weighted h	Square root of AWCR to avoid punishing researcher's with few very highly cited papers. Approximates h index
<b>33</b>	Citation/publication/author/time	<b>AWCRpa</b>	Per-author AWCR	Number of citations to all publications adjusted for age of each paper and number of authors
<b>34</b>	Citation/publication /time	<b>M quotient</b>	m-quotient	Age weighted h. H divided by years since first publication
<b>35</b>	Citation/publication/time	<b>Mg</b>	Mg-quotient	Age weighted g. G divided by years since first publication
<b>36</b>	Citation/publication/time	<b>PI</b>	Price Index	Percentage references to documents not older than 5 years at the time of publication of the citing sources
<b>37</b>	Citation/publication/field	<b>IQP</b>	Index of Quality & Productivity	Number of citations a scholar's work would receive if it is of average quality in the field
<b>Journal-field benchmarks, calculated by CWTS</b>				
<b>38</b>			<b>mcs</b>	Mean citation score
<b>39</b>			<b>mncs</b>	Mean normalized citation score.
<b>40</b>			<b>pp top n cites</b>	Proportion of top papers
<b>41</b>			<b>pp top prop</b>	Proportion in top 10% of world
<b>42</b>			<b>pp uncited</b>	Proportion uncited
<b>43</b>			<b>mjs mcs</b>	Crown-type indicator
<b>44</b>			<b>mnjs</b>	Mean normalized journal score
<b>45</b>			<b>mjs pp top n cites</b>	Crown-type indicator
<b>46</b>			<b>mnjs pp top prop</b>	Crown-type indicator
<b>47</b>			<b>mjs pp uncited</b>	Crown type indicator
<b>48</b>			<b>prop self cites</b>	Proportion self-citations
<b>49</b>			<b>int coverage</b>	Internal coverage.
<b>50</b>			<b>pp collaboration</b>	collaboration
<b>51</b>			<b>pp int collab</b>	International collaboration
<b>52</b>			<b>n self cites</b>	Number of self-citations

**Figure 1. Relationship between the analysed indicators and the publication activities they purport to measure.**



## 4 Results

### 4.1 Association between seniority and bibliometric indicators

The assumption behind this analysis is that knowing the seniority of the researcher will improve the prediction of the performance of the indicator.

We used *gamma* as the symmetric measure of association and cross-tabulated seniority and the bibliometric indicators, discipline by discipline. The value of gamma tends to be large due to how it is calculated, so Kendall's tau-c (for non-square tables – like a 2 x 3 table) are often preferred. Gamma is a Proportional Reduction of Error, which is interpreted as the improvement in predicting the dependent variable that can be attributed to knowing a case's value on the independent variable. Because gamma is a proportional reduction in error we can suggest that the following indicators are potential useful predictors of discipline specific seniority performance, Table 5. For simplicity we report only the indicators that are improved by  $\geq 10\%$ .

#### *Astronomy*

Knowing the seniority of the researcher will improve the prediction of the performance of **minimum number of citations** (51%), **Price Index** (20%), **minimum mjs mcs** (23%), **average mjs** (12%) and **normalized h** (16%).

#### *Environmental Science*

Knowing the seniority of the researcher will improve the prediction of the performance of **minimum citations** (25%), **Years since first publication** (24%), **Citations** (11%), **Publications** (16%), **Fractionalized papers** (18%), **number not cited papers** (17%), **Citation age** (18%), **Most significant paper** (10%), **Cites minus self-citations** (12%), **Fractional citations** (14%), **sum pp top n cites** (12%), **sum pp top prop** (16%), **h index** (14%), **g** (10%), **h2** (11%) and **POP h** (13%).

#### *Philosophy*

Knowing the seniority of the researcher will improve the prediction of the performance of **Years since first publication** (18%) and **Wu** (16%).

#### *Public Health*

Knowing the seniority of the researcher will improve the prediction of the performance of **AWCR\_pp** (13%), **minimum citations** (36%), **minimum mjs mcs** (13%), and **times cited more frequently than the average paper in the discipline** (12%).

#### *Across all disciplines*

Knowing the seniority of the researcher will improve the prediction of the performance of **number not cited** (19%) and **percent not cited** (49%). All other indicators displayed minimum or no association.

**Table 5. Analysis of prediction power of bibliometric indicators when knowing the seniority of a researcher. Proportional Reduction of Error gamma values of 10% or more are interpreted as indicating an association.**

Discipline	No association	Minimal association ≤10%	Moderate association 11~50%	Strong association ≥51%
<i>Astronomy</i>	App, Pyrs, cpp, c, p, fp, nnc, %nc, %sc, cage, AWCR_c, AW, AWCR_au, Sig, h, C-sc, Fc, sum pp top n cit, sum pp top prop, average mjs mcs, max mjs mcs, IQP, mg, e q2, h2, AR, POPh, productivity adjusted papers, h, mquot, m, A, R, g, hg, WU, cites <5 yrs	AWCR_pp, times cited more frequently than average papers	PI, min mjs mcs, average mjs, h norm	min n cites (51%)
<i>Environmental Science</i>	App, %sc, %nc, AWCR_pp, PI, min mjsmcs, times cited more frequently than average papers, mquot, hnorm, wu, mg, AR	Cpp, sc, AWCR_c, AWCR_au, AW, max cites, average mjs mcs, max mjs mcs, IQP, m, A, R, e, q2, h2, cites <5yrs	Pyrs, C, P, fp, nnc, cage, sig, h, min cites, max cites, c-sc, fc, sum pp top n cites, sum pp top prop, Nproductivity adjusted papers, h, g, hg, poph	-
<i>Philosophy</i>	%sc, %nc, AWCR_pp, AWCR_au, min cites, PI, min mjs mcs, gennemsnit mnjs, times cited more frequently than average papers, mquot, hnorm, mg	App, cpp, c, sc, p, fp, nnc, cage, AWCR_c, AW, sig, h, C-sc, fc, sum pp top n cites, sum pp top prop, average mjs mcs, max mjs mcs, IQP, h, m, A, R, g, hg, wu, e, q2, h2, AR, hpop, cites <5yrs	Pyrs, nproductivity adjusted papers,	-
<i>Public Health</i>	Pyrs, P, Fp, nnc, %nc, cage, AWCR_au, max cites, sig, Fc, PI, productivity adjusted papers, h, Q2, poph	App, cpp, c, sc, %sc, AWCR_c, AW, cites <5yrs, AR, h, c-sc, sum pp top n cites, sum pp top prop, average mjs mcs, min mjs mcs, max mjs mcs, average mnjs, IQP, mquot, hnorm, m, A, R, g, hg, mg, e, h2	AWCR_pp, min cites, times cited more frequently than average paper,	-

Generally the prediction of the performance of h-type indicators to seniority was minimal or no association. This makes sense, as these indicators are dependent on citations and publications also being predictors of performance on a seniority level, which is only the case in *Environmental Science*. That is why we can only indicate a trend towards h-type indicators being a performance predictor on seniority level in the discipline of *Environmental Science*, and that said the improvement is only between 9-14%. Across *Astronomy*, *Environmental Science* and *Public Health* there appears to be a trend towards a minimum citation limit within seniority, as **minimum citations** is a moderate to strong indicator of performance, 25-51%. This echoes' our findings in the Google Scholar data (WP5 deliverable 5.4.b) where we concluded that minimum citations per paper (**minCPP**) can be used as expected seniority performance benchmarks. Whereas in Google Scholar **minCPP** was a strong indicator, on this WoS data **minimum total citations** is a better associative indicator, thus illustrating

that indicators do not only perform differently between disciplines but also between citation indexes or versions of the same citation index used to collect the data.

## 4.2 Identifying central indicators across disciplines

In this analysis we are inspired by Franceschet (2009) and analyse which indicators display high correlations to other indicators. The purpose is on one hand to identify indicators that are highly correlated to other indicators, and on the other to identify indicators that practically measure the same inherent properties. If indicators can be grouped by such an analysis into clusters of highly similar indicators, then the simpler alternatives from each cluster can be recommended over more complex ones – thus making it more feasible for individuals to calculate them.

We first attempt to identify central indicators for each discipline and then compare across disciplines. To answer this question we constructed correlation matrixes of the sample for each discipline. The Kendall correlation matrixes are shown in Appendix 3-6.

Table 6 uses data from the correlation matrixes to highlight isolated indicators, meaning that they do not have any strong links, defined as over 0.7, to any other indicator in the correlation. In the third column of the table the most central indicators are highlighted, that is the indicators with the highest number of links over 0.7 to other indicators in the matrix (indicated in column 4).

**Table 6. Isolated and highly correlated indicators across disciplines.**

Discipline	Isolated Indicators	Central Indicators	Number of links to other indicators
<i>Astronomy</i>	App, sum sc, AWCR_pp, fp, %nc, average mjs mcs, min mjs mcs, maxs mjs mcs, average mnjs, h norm, wu	Hg IQP, AR	25 24
<i>Environmental Science</i>	Pyr, App, %sc, Fp, nnc, %nc, Cage, AWCR_pp, PI, average mnjs, min mjs mcs, maxs mjs mcs, nproductivity adjusted papers, wu, AR	H, h2 popH, Q2, e, IQP	26 25
<i>Philosophy</i>	App, %sc, nnc, &nc, PI, sum pp top prop, average mjs mcs, max mjs mcs, average mnjs, nproductivity adjusted papers, hnorm, Wu	IQP AR, h2, Q2, e, g, h	28 27
<i>Public Health</i>	Pyr, app, %sc, nnc, %nc, cage, AWCR_pp, minC, PI, min mjs mcs, average mnjs, nproductivity adjusted papers, hnorm, Wu	g Hg, h, h2	23 22

The central indicators all hybrid indicators, that is, indicators that in their calculations adjust in some form citations to number of publications. To investigate the role of the identified central indicators, we ranked researchers within disciplines and mapped how their position in the ranks changes when using the central indicators as the control. We identified the top 10%, top 25%, middle 50% and bottom 25% in each set. In *Astronomy* we used the **hg** index as the ranking factor, in *Environmental Science* the **h** index, in *Philosophy* the **IQP** index and in *Public Health* we used the **g** index. Across all disciplines we observed the same trend. If a researcher is placed in the top 10% of the sample by the central indicator, the researcher is placed in the top 10% using the other indicators that the central

indicator has strong links to. Likewise, for researchers in the top 25%, middle 50% and bottom 25%. For example a researcher in **Public Health** scores in the middle 50% on the **g** index, will be placed in the middle 50% on the other 23 indicators the **g** index has strong links to. The **g** index has strong links to **C, sc, P, AWCR, AWCR\_au, AW, max cites, Sig, Fc, sum top pp prop, sum pp top prop, IQP, h, m, A, R, hg, e, h, Q2, h2, AR** and **POPh**. This group represents indicators of production, crown type indicators, hybrid indicators and raw publication and citation counts. Further we noticed that the isolated indicators produce a very random rank, placing a researcher sometimes in the top 10% and sometimes in the bottom 25%. This observation needs to be supported by further statistical analyses, where we investigate the overlap between the central indicators and the indicators they link to, to understand which aspects of the effect of a researchers' production they capture.

### 4.3 Identifying central indicators for each discipline

Here we attempt to apply clustering techniques to recommend single indicators that represent independent aspects of research performance. To continue the analysis of central indicators and how they cluster other indicators around them we now consider the output of the correlation analysis using the ALSCAL procedure in SPSS. The clustering is shown as two-dimensional models of Euclidean distance (i.e. maps), which illustrate the association between indicators by measuring the distance between them as points on a two-dimensional plane with coordinates (x,y) and (a,b). To get an idea of how well the clustering model fits the data, we report the S-stress as a measure of fit ranging from 1 (worst possible fit) to 0 (perfect fit) and R-square to illustrate how much of the variance in the model is explained by the two dimensions. In general, in the results presented below the fit is low and the stress high indicating that the maps do not capture the complexity of higher dimensions that well when transformed into 2 dimensions. For this reason we choose to supplement the maps with a hierarchical clustering algorithm that starts the clustering with the pair of indicators that have smallest squared Euclidean distance between them. The output is a dendrogram – i.e. a tree diagram that illustrates the arrangement of clusters. The branch-like nature of the dendrogram allows you to trace backward or forward to any individual case or cluster at any level. In addition it gives an idea of how great the distance is between cases or groups that are clustered in a particular step, using a 0-25 scale along the top of the chart. While it is difficult to interpret distance in the early clustering phases (the extreme left of the chart), as you move to the right relative distance become more apparent. The bigger the distances before two clusters are joined, the bigger the differences in these clusters. To find membership of a particular cluster trace backwards down the branches to the name.

#### 4.3.1 Astronomy

The central indicator for astronomy is the hg index, marked with an arrow. S-stress=0,375 and  $R^2=0,253$ , only 25% variance is explained by the model. This is a very coarse grouping of indicators.

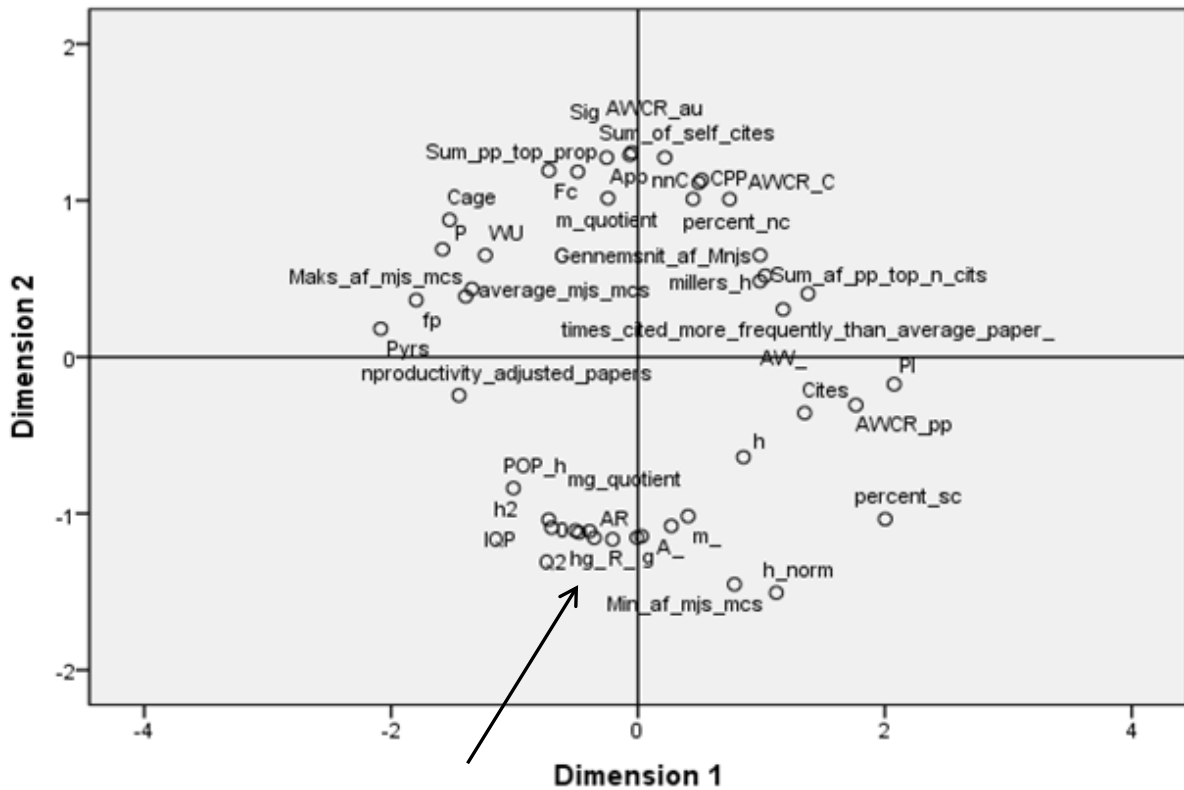


Figure 2. Multidimensional Scaling map of the studied bibliometric for Astronomy.

The indicators are roughly grouped into 3 correlation clusters, the most intense cluster is the hybrid indicators that group around the **hg** index. The second cluster is heavily dominated by publication based indicators, which gather in an arch at the top of the figure from **number of productivity adjusted papers** through to **AW** index. The third is a cluster of isolated indicators **%sc**, **PI**, **AWCR\_pp**, **hnorm** and **min mjs mcs**. Citations (C) and **h** index appear to fall outside the clusters.



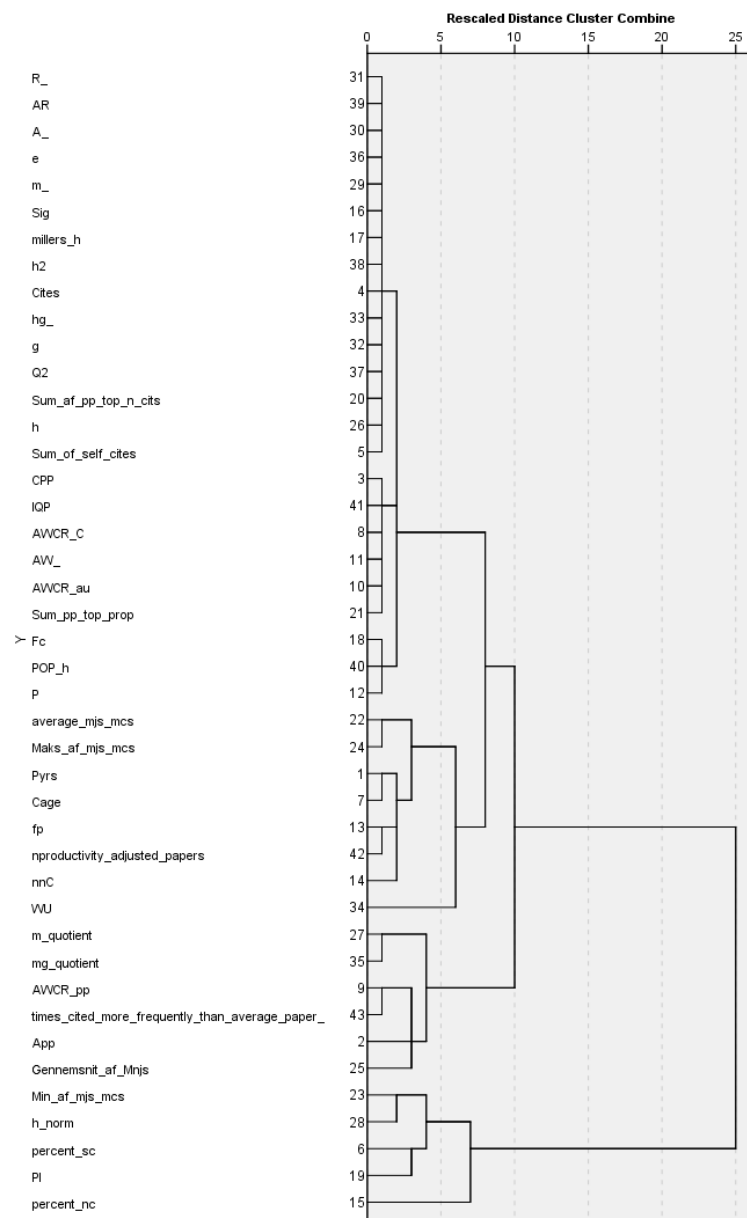


Figure 3. Hierarchical clustering dendrogram of the studied bibliometric for Astronomy.

Our observations about isolated indicators are confirmed. These indicators potentially measure researcher impact not covered by the other indicators. The resulting partition contains 4 clusters. One main cluster of hybrid indicators (**R** through **Sc**), and three smaller clusters that illustrate less intense relationships between the indicators. These clusters have expected field performance indicators (crown indicators) mixed in with them: paper-based metrics (**CPP** to **Sum pp top prop**), production adjusted for age or discipline (**average mjs mcs** through **Wu**) and finally a mix of time dependent metrics and researcher-adjusted metrics.

#### 4.3.2 Environmental Science

The model explains 24% of the variance ( $R^2$ ),  $S$ -stress=0.378. The central indicators **h** and **h2** are marked with arrows and fall within the same cluster. Four clear clusters are visible with **percent sc** falling outside of these. These four identifiable groups are hybrid indicators, cite-based indicators, indicators of production and crown type indicators (expected field performance).

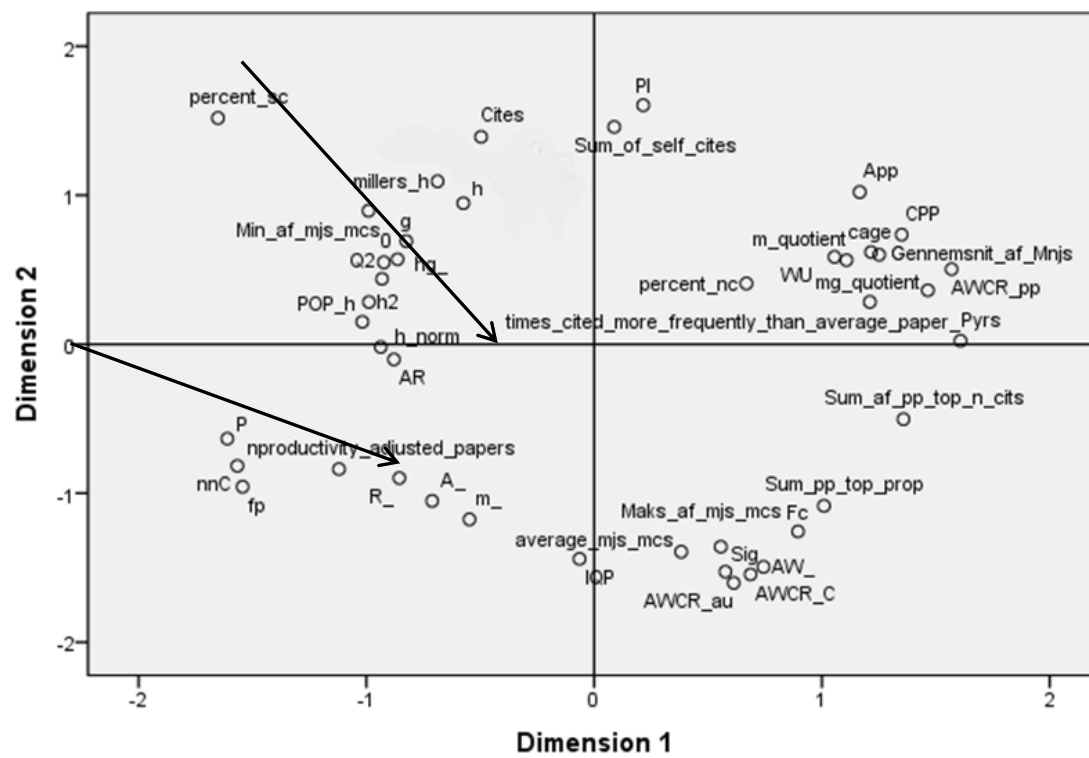


Figure 4. Multidimensional Scaling map of the studied bibliometric for *Environmental Science*.

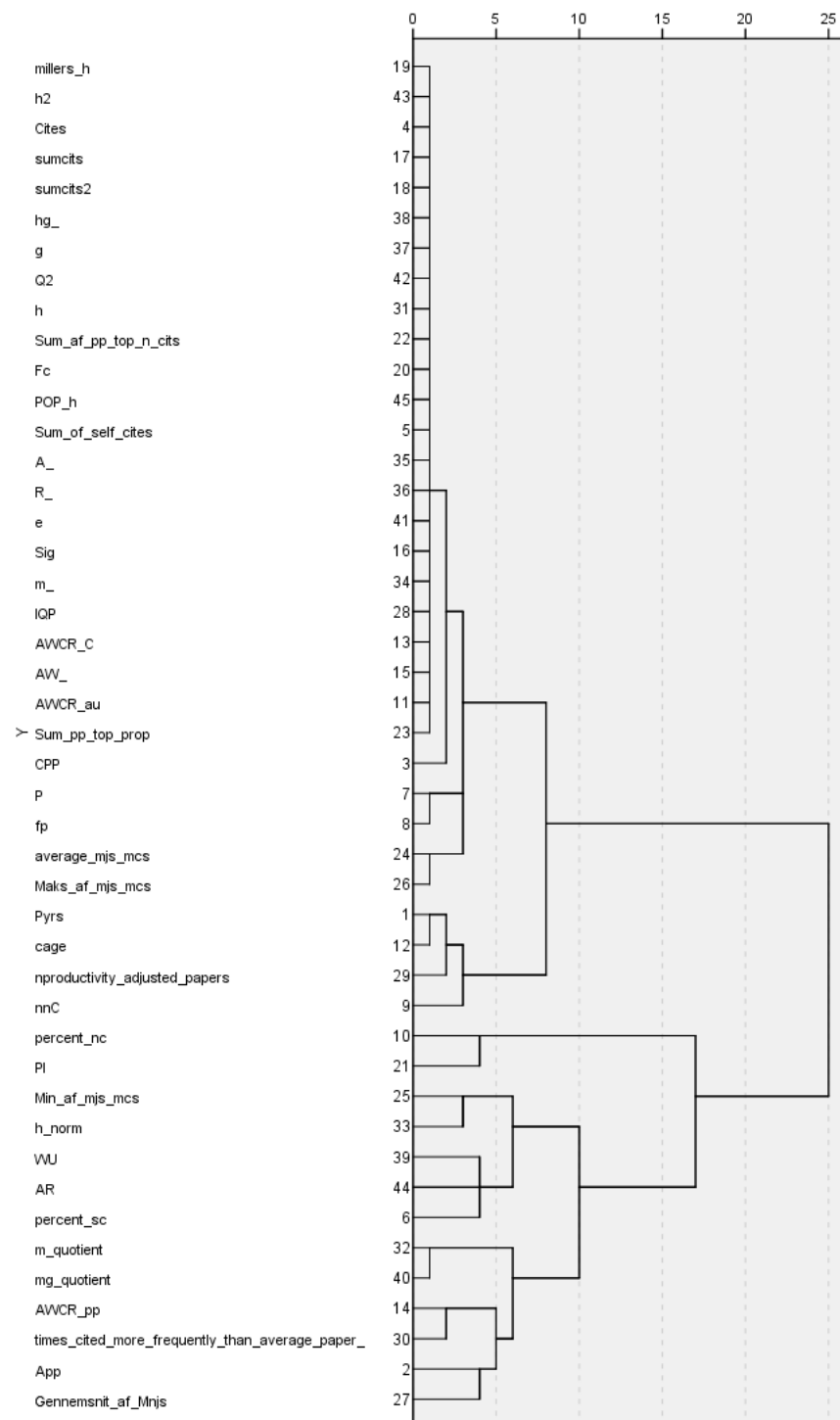


Figure 5. Hierarchical clustering dendrogram of the studied bibliometric for *Environmental Science*.

The distance between the clusters is easier to read in the dendrogram. The hybrid h indicators (**millers\_h** through **sum pp top prop**) form a tight group, while the remaining indicators form 6 smaller and more loosely related groups. The paper-based indicators **p** and **fp** form one group, indicators of production another group (**Pyrs**, **Cage**, **nproductivity adjusted papers** and **nnC**), the isolated indicators (**%nc** and **PI**); a seemingly random cluster of indicators (**min mjs mcs** to **%sc**), the crown indicators **average mjs mcs**, **max mjs mcs**; and finally indicators that account for age or time (**m-quotient** through **average of mnjs**).

### 4.3.3 Philosophy

The model is a better fit,  $R^2$  explaining 47% of the variance. S-stress=0.38. The central indicator **IQP** is marked with an arrow. Three clusters are presented. Hybrid indicators group at the top of the figure (**A** through **mg-quotient**), a group of paper-based indicators in the top left (**times cited more frequently than average paper to P**) and a large mixed group of the remaining indicators that includes our central indicator. The **Percent not cited** indicator falls outside any grouping.

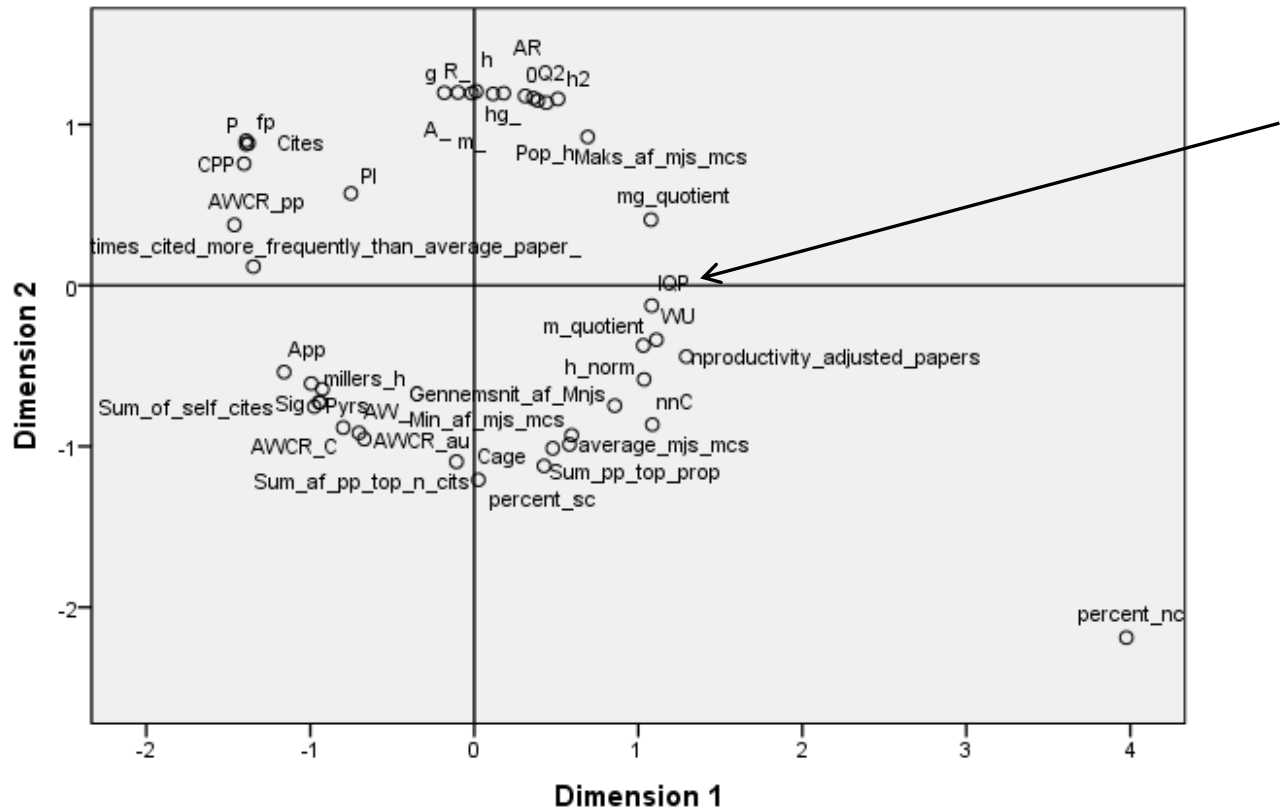


Figure 6. Multidimensional Scaling map of the studied bibliometric for *Philosophy*.

The dendrogram illustrates the distance of the groups of indicators from each other. The hybrid and crown-type indicators are closely related and group strongly with a second cluster of production indicators (**p** through **average of mnjs**). More distant relations with the cluster of ratio based indicators are illustrated, **AWCR\_pp** through **h\_norm**, and with the fourth group that consists of a mix of time, citation and paper adjusted indicators. **Percent not cited** and **PI** (price index) are only related to the other indicators on a very distant level.

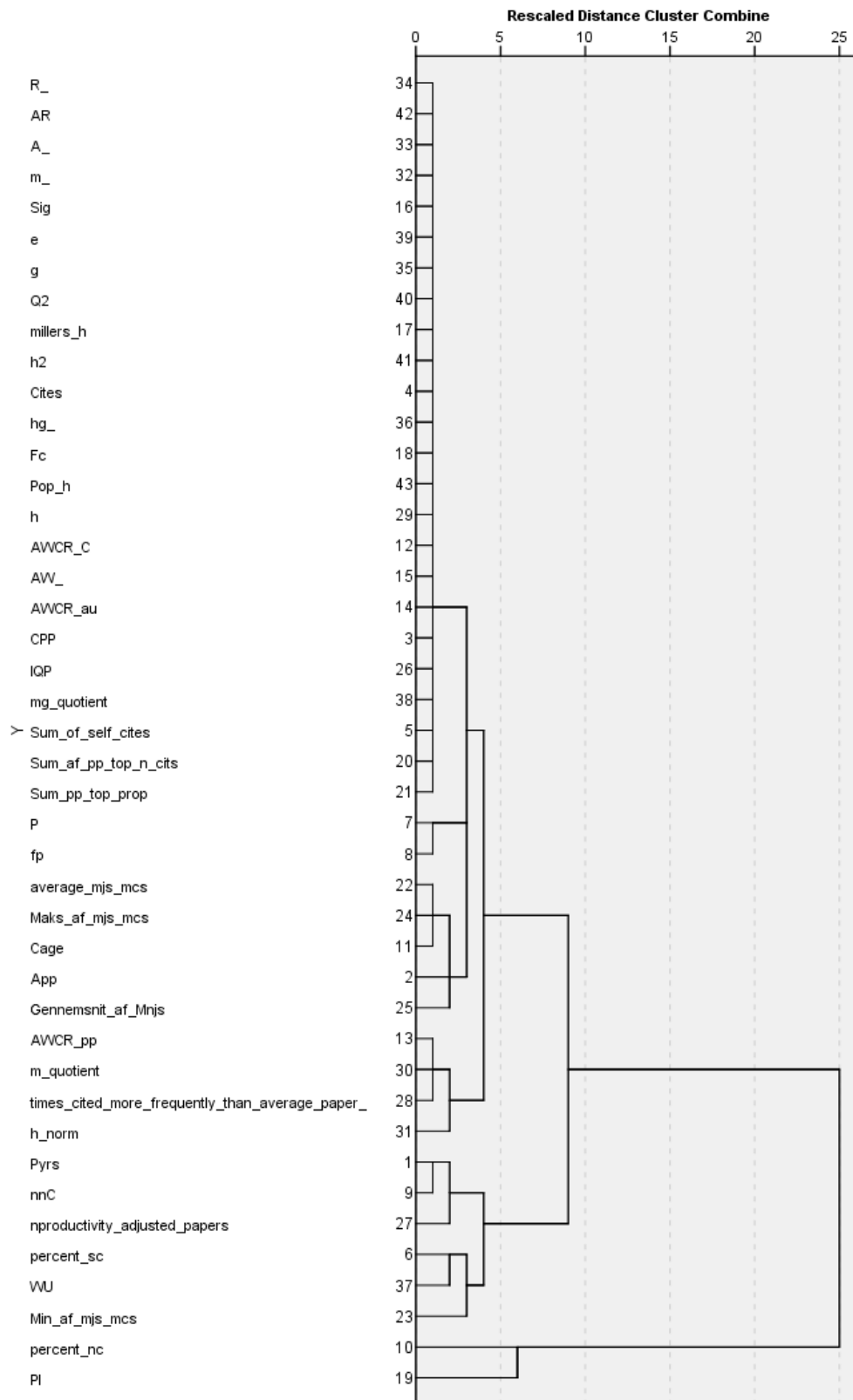


Figure 7. Hierarchical clustering dendrogram of the studied bibliometric for *Philosophy*.

#### 4.3.4 Public Health

38% of the variance is explained by the model ( $R^2$ ), S-stress=0.499. The central indicator **g** is marked with an arrow. It is very difficult to deduce independent clusters in the distance model, below. We suggest two clusters. The small cluster in the bottom right of the frame, from **AWCR\_pp** to **min mjs**

**mcs**, and the large cluster of remaining indicators that spread across the centre of the diagram. **Publication years (PyrS)** is the clear outlier.

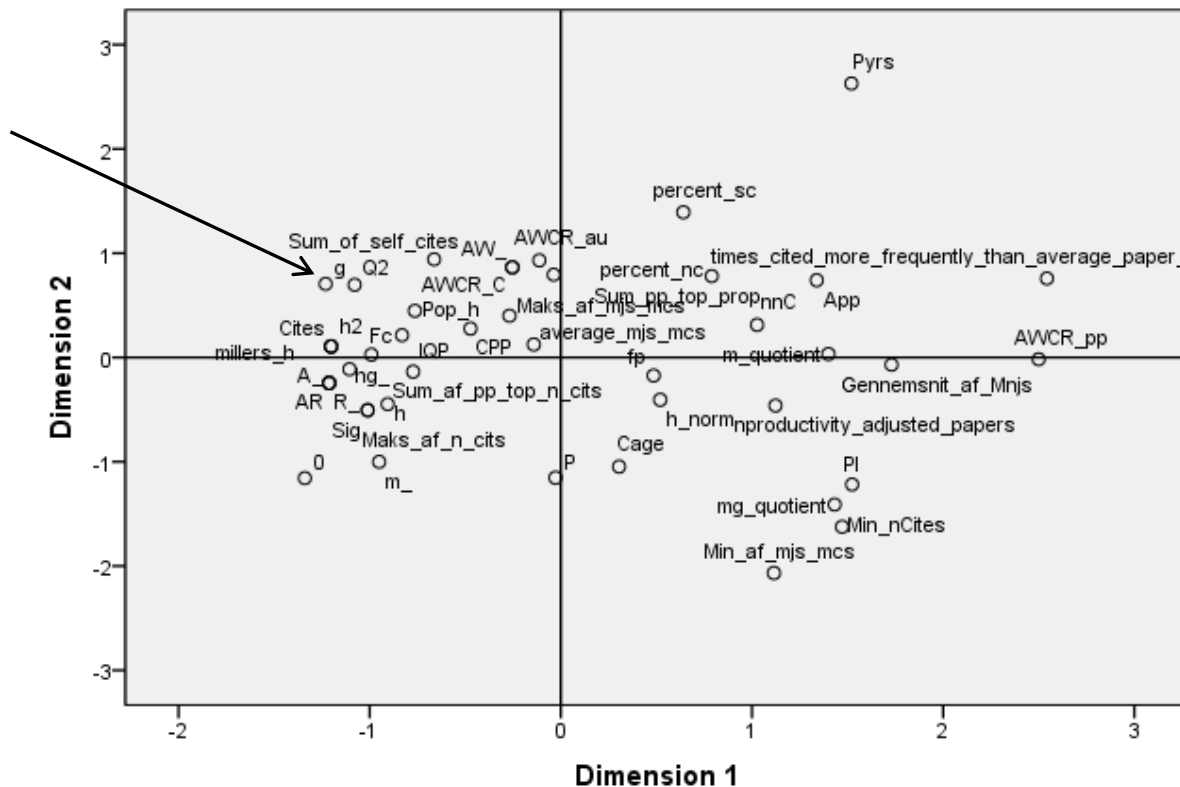


Figure 8. Multidimensional Scaling map of the studied bibliometric for *Public Health*.

The dendrogram is more informative. Hybrid indicators and indicators adjusted for author contribution form one large cluster, and are closely related to two crown indicators (**average mjs mcs** and **maks mjs mcs**). Paper-based metrics form their own cluster (**PyrS** through **productivity adjusted papers**). The last three clusters are distantly related to the aforementioned clusters and the indicators within these three only loosely related to each other. Hence they present groupings of miscellaneous indicators. Again the **%not cited**, **% self-citations** and **Price Index (PI)** are only very distantly related to the other indicators.

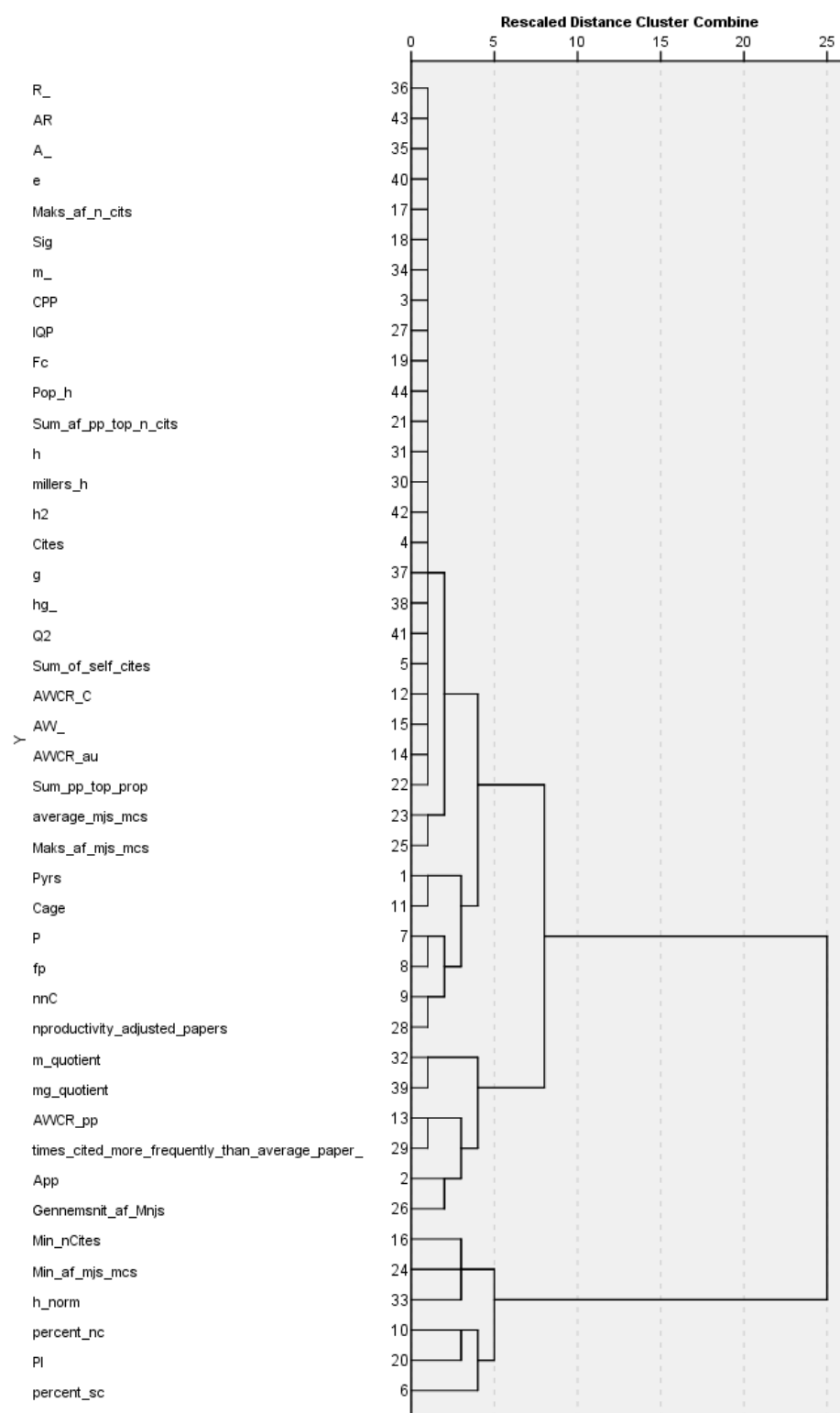


Figure 9. Hierarchical clustering dendrogram of the studied bibliometric for *Public Health*.

#### 4.3.5 Discussion and recommendations

We posed the question if using clustering structures is a good method to recommend single indicators that represent independent aspects of research performance. The hierarchical clustering illustrates that choosing one central indicator will not measure all aspects of the effects of a researchers publication. At an overall level, the indicators group together in indicators of production, citations, production & citations, production adjusted for time, production adjusted for discipline and miscellaneous isolated indicators that measure the more subjective aspects of a researcher's publishing portfolio. We note that the clustering of indicators is different from discipline to discipline, and no unified picture emerges across the disciplines. However, in each of the disciplines our analysis has identified central indicators and isolated indicators.

Isolated indicators are interesting because they measure aspects of the effect of publications not captured by other indicators. The **Price Index** for instance, identifies the currency of citations to papers: Is a citation count due to recent papers or papers published many years ago? A moderate association was found between knowing the seniority of the researcher and predicting the researcher's performance using isolated indicators.

Identifying central indicators illustrates the different roles of citations in the four disciplines and the power a single indicator has in researcher rankings. Interestingly for Philosophy it is an indicator that adjusts for disciplinary expected average citations and publishing age of the researcher, the **IQP** indicator. The other three disciplines that have a strong tradition for publishing and citations display the same preference for hybrid indicators. In *Astronomy* the **Hg** index is central. **Hg** is more granular than **h** and **g** indices, minimizes the effect of very highly cited papers to calculate a fairer version of the **h** index. This makes sense, as it is a disciplinary trait in our *Astronomy* set, that researchers commonly have one or two multi-authored papers that are very highly cited. In *Public Health* the **g** index is the central indicator, and as such is sensitive to highly cited papers – a criticism of the **h** index that ignores high performing papers. Further it is usual to find different scientists with same **h** but different number of publications and cites. The **g** index presents a granular solution good for a discipline that has a strong tradition of publishing and citing. *Environmental Science* groups also around the **h** and **h2** index, which can be used together as **h** suffers from the flaw of ignoring highly cited papers and the aforementioned flaw on granularity.

If we were to recommend a performance indicator for each discipline, for each type of indicator of activity, we would need to investigate the role of the indicators within their cluster: what they measure, if they overlap, how complicated they are and which are redundant.



Table 7. Calculation of the central indicators.

Discipline	Indicator	Calculation	Type
<i>Astronomy</i>	<b>Hg</b>	The square root of ( <b>h</b> multiplied by <b>g</b> ).	Citation/publication
<i>Environmental Science</i>	<b>H or H2</b>	Publications are ranked in descending order after number of citations. Where number of citations and rank is the same, this is the <b>h</b> index Cube root of total citations	Citation/publication
<i>Philosophy</i>	<b>IQP</b>	a) $A = (mnjs \times Pyrs \times p+1)/2$ . (number of citations if author was of average quality for field) b) $A/\text{number of papers}$ (estimated performance per paper) c) define actual number of citations d) $IQP = \text{actual citations}/b + \text{number of papers}$ e) calculate field impact per paper x number of papers $IQP = \text{expected average performance of scholar in the field, amount of papers that are cited more frequently than average and how much more than average they are cited}$ ( $Tc > a$ )	Citation/publications adjusted to field and age
<i>Public Health</i>	<b>g</b>	Publications are ranked in descending order after number of citations. The cumulative sum of citations is calculated, and where the square root of the cumulative sum is equal to the rank this is <b>g</b> -index	Citation/publication

## 5 Conclusion and recommendations

The clustering identified central and isolated indicators for each discipline. To investigate the role of the identified central indicators, we ranked authors within disciplines and mapped how their position in the ranks change when using the central indicators as the control. We identified the top 10%, top 25%, middle 50% and bottom 25% researchers in each set and found that certain indicators appear to control rank position. These central indicators differed from discipline to discipline. In Astronomy the hg index was the central indicator, in Environmental Science the h index, in Philosophy the IQP index and in Public Health the g index. Across all disciplines we observed the same trend. If a researcher is placed in the top 10% of the sample ranking by the central indicator, the researcher is placed in the top 10% using the other

indicators the central indicator has strong links to. The same holds for authors in the top 25%, middle 50% and bottom 25%. We also noticed that isolated indicators, PI, %nc, %sc have no strong links to other indicators and produce a very random rank positions. However, they do indicate activities that are not covered by the other indicators.

These observations need to be explored and deepened in further statistical analyses that investigate the overlap between the central indicators and the indicators they link to as well as the aspects of the effect of an authors' production they capture. Using a hierarchical clustering model that illustrated how closely related the indicators are to each other, we discovered that indicators group together in descriptors of production, citations, production & citations, production adjusted for time, production adjusted for field and miscellaneous measures that describe the more subjective aspects of a researcher's publishing portfolio. The clustering of indicators is different from discipline to discipline, as is the strength of their relation. If we were to recommend a performance indicator for each field, for each type of indicator of activity, we would need to investigate the role of the indicators within their cluster: what they measure, if they overlap, how complicated they are and which of them are redundant. The m-quotient displayed stability within disciplines and comparability across databases, please see the continuation of this study in the supplementary material.

## 6 Limitations

The bibliometric indicators tested in our study discriminate between high and low performing researchers, but proved ineffective in discriminating between mediocre researchers in the middle quartiles.

The values of citation analysis in junior researchers is questioned as papers accumulate citations over many years after publication, and junior researchers do not in this respect have time on their side in bibliometric evaluation. Time is a factor that must be adjusted for when comparing researcher impact.

The number of publications and citations required to make meaningful researcher assessments of junior scholars, scholars who publish in national languages and scholars who publish in other formats than articles in journals indexed in citation databases.. Other indicators of a researcher's scientific activities, not limited to publications in journals, must be considered such as altmetrics, network analysis and surveys. Our object has been to find that indicator most useful in five academic seniorities within four broad disciplines.

## 7 Acknowledgements

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- WP5 Deliverable 5.4b ACUMEN WP5 (2014) *Consequences of indicators: Using indicators on data from Google Scholar (Grant Agreement no.266632)* 7<sup>th</sup> Framework Programme, SP4- Capacities. Science in Society 2010

## Appendix 1: Effect of excluding proceedings papers

Researcher	Proceedings	All publications	% Proc.	Discipline	Seniority
1	4	40	10,0	astro	phd
3	1	16	6,3	astro	phd
4	2	27	7,4	astro	phd
5	3	5	60,0	astro	phd
8	4	11	36,4	astro	phd
9	5	8	62,5	astro	phd
14	4	22	18,2	astro	phd
17	1	15	6,7	astro	Post doc
22	3	16	18,8	astro	Post doc
23	6	59	10,2	astro	Post doc
24	4	13	30,8	astro	Post doc
27	4	13	30,8	astro	Post doc
28	4	44	9,1	astro	Post doc
30	2	11	18,2	astro	Post doc
31	50	100	50,0	astro	Post doc
32	4	19	21,1	astro	Post doc
33	2	48	4,2	astro	Post doc
36	5	108	4,6	astro	Post doc
37	12	29	41,4	astro	Post doc
38	1	4	25,0	astro	Post doc
39	7	21	33,3	astro	Post doc
40	3	23	13,0	astro	Post doc
41	4	40	10,0	astro	Post doc
43	3	17	17,6	astro	Post doc
45	1	29	3,4	astro	Post doc
47	8	33	24,2	astro	Post doc
48	2	32	6,3	astro	Post doc
49	1	70	1,4	astro	Post doc
50	1	27	3,7	astro	Post doc
51	3	35	8,6	astro	Post doc
52	5	41	12,2	astro	Post doc
53	6	49	12,2	astro	Post doc
54	5	87	5,7	astro	Post doc
56	1	59	1,7	astro	Post doc
57	4	25	16,0	astro	Post doc
58	1	17	5,9	astro	Post doc
59	4	12	33,3	astro	Post doc
60	19	30	63,3	astro	Post doc
61	4	14	28,6	astro	Post doc
62	3	22	13,6	astro	Post doc
63	1	12	8,3	astro	Post doc
64	3	16	18,8	astro	Post doc
65	11	105	10,5	astro	Assis Prof
68	8	43	18,6	astro	Assis Prof
69	20	121	16,5	astro	Assis Prof
70	19	45	42,2	astro	Assis Prof

71	3	13	23,1	astro	Assis Prof
72	10	37	27,0	astro	Assis Prof
73	15	157	9,6	astro	Assis Prof
74	6	41	14,6	astro	Assis Prof
75	2	32	6,3	astro	Assis Prof
76	13	61	21,3	astro	Assis Prof
78	2	48	4,2	astro	Assis Prof
79	5	76	6,6	astro	Assis Prof
81	6	56	10,7	astro	Assis Prof
83	2	34	5,9	astro	Assis Prof
84	4	71	5,6	astro	Assis Prof
85	7	74	9,5	astro	Assis Prof
86	25	58	43,1	astro	Assis Prof
87	21	65	32,3	astro	Assis Prof
88	2	25	8,0	astro	Assis Prof
89	1	17	5,9	astro	Assis Prof
90	10	40	25,0	astro	Assis Prof
91	23	151	15,2	astro	Assis Prof
92	4	68	5,9	astro	Assoc
93	4	52	7,7	astro	Assoc
96	4	47	8,5	astro	Assoc
97	8	28	28,6	astro	Assoc
98	14	153	9,2	astro	Assoc
99	9	83	10,8	astro	Assoc
100	24	84	28,6	astro	Assoc
101	10	62	16,1	astro	Assoc
102	31	154	20,1	astro	Assoc
103	11	28	39,3	astro	Assoc
104	3	27	11,1	astro	Assoc
105	24	124	19,4	astro	Assoc
106	1	8	12,5	astro	Assoc
107	23	315	7,3	astro	Assoc
108	62	149	41,6	astro	Assoc
109	3	38	7,9	astro	Assoc
110	16	91	17,6	astro	Assoc
111	15	104	14,4	astro	Assoc
112	3	17	17,6	astro	Assoc
113	4	30	13,3	astro	Assoc
114	7	57	12,3	astro	Assoc
115	24	105	22,9	astro	Assoc
116	5	60	8,3	astro	Assoc
117	9	78	11,5	astro	Assoc
118	34	163	20,9	astro	Assoc
119	25	94	26,6	astro	Assoc
120	16	59	27,1	astro	Assoc
122	24	197	12,2	astro	Assoc
123	14	169	8,3	astro	Assoc
124	1	50	2,0	astro	Assoc
125	19	47	40,4	astro	Assoc
126	1	87	1,1	astro	Assoc
127	29	131	22,1	astro	Assoc
128	13	76	17,1	astro	Assoc
129	23	68	33,8	astro	Assoc

130	18	66	27,3	astro	Assoc
132	8	46	17,4	astro	Assoc
134	30	211	14,2	astro	Assoc
135	28	149	18,8	astro	Assoc
136	12	48	25,0	astro	Assoc
137	15	87	17,2	astro	Assoc
138	4	56	7,1	astro	Assoc
139	7	16	43,8	astro	Assoc
140	11	104	10,6	astro	Assoc
143	7	44	15,9	astro	Assoc
144	8	133	6,0	astro	Assoc
146	16	58	27,6	astro	Assoc
147	15	194	7,7	astro	Assoc
148	11	62	17,7	astro	Assoc
149	3	32	9,4	astro	Assoc
150	5	28	17,9	astro	Assoc
151	13	35	37,1	astro	Assoc
152	1	79	1,3	astro	Assoc
153	21	97	21,6	astro	Assoc
154	12	121	9,9	astro	Assoc
155	73	279	26,2	astro	Assoc
156	40	51	78,4	astro	Assoc
157	27	93	29,0	astro	Assoc
158	9	132	6,8	astro	Assoc
159	75	334	22,5	astro	Assoc
160	8	40	20,0	astro	Assoc
161	4	149	2,7	astro	Assoc
162	20	178	11,2	astro	Assoc
163	7	40	17,5	astro	Assoc
164	14	334	4,2	astro	Prof
165	16	64	25,0	astro	Prof
166	14	75	18,7	astro	Prof
168	17	113	15,0	astro	Prof
169	3	50	6,0	astro	Prof
170	4	82	4,9	astro	Prof
171	12	116	10,3	astro	Prof
172	22	58	37,9	astro	Prof
173	100	271	36,9	astro	Prof
174	33	252	13,1	astro	Prof
175	8	121	6,6	astro	Prof
176	3	78	3,8	astro	Prof
177	8	118	6,8	astro	Prof
178	26	110	23,6	astro	Prof
179	3	56	5,4	astro	Prof
180	5	60	8,3	astro	Prof
181	32	137	23,4	astro	Prof
182	100	427	23,4	astro	Prof
183	93	372	25,0	astro	Prof
184	15	88	17,0	astro	Prof
185	58	239	24,3	astro	Prof
186	9	43	20,9	astro	Prof
187	9	105	8,6	astro	Prof
189	7	88	8,0	astro	Prof

190	39	120	32,5	astro	Prof
191	36	140	25,7	astro	Prof
192	45	166	27,1	astro	Prof
193	16	227	7,0	astro	Prof
194	5	95	5,3	astro	Prof
195	6	94	6,4	astro	Prof
196	93	353	26,3	astro	Prof
197	7	143	4,9	astro	Prof
198	51	123	41,5	astro	Prof
199	8	60	13,3	astro	Prof
200	97	422	23,0	astro	Prof
203	3	73	4,1	astro	Prof
206	1	6	16,7	enviro	Phd
212	1	9	11,1	enviro	Post doc
214	10	18	55,6	enviro	Post doc
216	5	38	13,2	enviro	Post doc
220	12	25	48,0	enviro	Post doc
221	13	72	18,1	enviro	Post doc
222	4	13	30,8	enviro	Post doc
223	10	25	40,0	enviro	Post doc
228	1	21	4,8	enviro	Assis Prof
234	1	20	5,0	enviro	Assis Prof
237	2	17	11,8	enviro	Assis Prof
238	1	46	2,2	enviro	Assis Prof
240	1	10	10,0	enviro	Assis Prof
241	1	10	10,0	enviro	Assis Prof
244	8	27	29,6	enviro	Assis Prof
245	1	13	7,7	enviro	Assis Prof
247	5	40	12,5	enviro	Assis Prof
249	1	12	8,3	enviro	Assis Prof
250	6	45	13,3	enviro	Assis Prof
253	5	28	17,9	enviro	Assis Prof
255	5	51	9,8	enviro	Assis Prof
258	2	15	13,3	enviro	Assis Prof
259	5	34	14,7	enviro	Assis Prof
260	9	23	39,1	enviro	Assis Prof
261	1	9	11,1	enviro	Assis Prof
264	2	40	5,0	enviro	Assis Prof
266	1	17	5,9	enviro	Assis Prof
268	3	76	3,9	enviro	Assoc
269	2	48	4,2	enviro	Assoc
270	5	67	7,5	enviro	Assoc
271	3	55	5,5	enviro	Assoc
272	1	21	4,8	enviro	Assoc
274	1	19	5,3	enviro	Assoc
275	1	7	14,3	enviro	Assoc
278	2	43	4,7	enviro	Assoc
280	1	49	2,0	enviro	Assoc
282	1	53	1,9	enviro	Assoc
284	7	32	21,9	enviro	Assoc
285	3	51	5,9	enviro	Assoc
286	11	102	10,8	enviro	Assoc
287	4	16	25,0	enviro	Assoc

288	1	4	25,0	enviro	Assoc
290	1	10	10,0	enviro	Assoc
291	1	30	3,3	enviro	Assoc
292	4	20	20,0	enviro	Assoc
294	1	15	6,7	enviro	Assoc
297	3	27	11,1	enviro	Assoc
298	1	11	9,1	enviro	Assoc
299	8	33	24,2	enviro	Assoc
300	2	10	20,0	enviro	Assoc
301	1	37	2,7	enviro	Assoc
302	1	44	2,3	enviro	Assoc
303	8	41	19,5	enviro	Assoc
304	5	50	10,0	enviro	Assoc
306	3	51	5,9	enviro	Assoc
307	7	65	10,8	enviro	Assoc
308	12	30	40,0	enviro	Assoc
309	2	25	8,0	enviro	Assoc
311	5	54	9,3	enviro	Assoc
312	8	66	12,1	enviro	Assoc
313	1	50	2,0	enviro	Assoc
314	1	25	4,0	enviro	Assoc
315	1	28	3,6	enviro	Assoc
316	8	49	16,3	enviro	Assoc
317	1	6	16,7	enviro	Assoc
318	11	38	28,9	enviro	Assoc
319	2	14	14,3	enviro	Assoc
322	3	32	9,4	enviro	Assoc
323	3	27	11,1	enviro	Assoc
325	4	74	5,4	enviro	Assoc
328	5	39	12,8	enviro	Assoc
329	5	69	7,2	enviro	Assoc
330	1	61	1,6	enviro	Assoc
331	2	22	9,1	enviro	Assoc
332	1	26	3,8	enviro	Assoc
333	15	29	51,7	enviro	Assoc
334	3	28	10,7	enviro	Assoc
335	1	6	16,7	enviro	Assoc
338	4	50	8,0	enviro	Assoc
340	3	57	5,3	enviro	Assoc
341	5	15	33,3	enviro	Assoc
343	13	28	46,4	enviro	Assoc
344	4	23	17,4	enviro	Assoc
345	11	113	9,7	enviro	Assoc
347	1	41	2,4	enviro	Assoc
348	1	27	3,7	enviro	Assoc
350	1	65	1,5	enviro	Assoc
351	3	20	15,0	enviro	Assoc
352	12	90	13,3	enviro	Prof
353	6	71	8,5	enviro	Prof
354	1	2	50,0	enviro	Prof
355	2	53	3,8	enviro	Prof
356	1	151	0,7	enviro	Prof
357	53	233	22,7	enviro	Prof



358	26	154	16,9	enviro	Prof
359	40	102	39,2	enviro	Prof
361	3	12	25,0	enviro	Prof
362	2	27	7,4	enviro	Prof
363	25	113	22,1	enviro	Prof
364	1	14	7,1	enviro	Prof
365	3	127	2,4	enviro	Prof
366	8	72	11,1	enviro	Prof
367	1	7	14,3	enviro	Prof
368	10	73	13,7	enviro	Prof
369	20	106	18,9	enviro	Prof
371	2	44	4,5	enviro	Prof
373	2	101	2,0	enviro	Prof
374	9	88	10,2	enviro	Prof
375	18	106	17,0	enviro	Prof
376	5	78	6,4	enviro	Prof
377	3	67	4,5	enviro	Prof
378	7	77	9,1	enviro	Prof
379	1	90	1,1	enviro	Prof
380	16	48	33,3	enviro	Prof
381	16	76	21,1	enviro	Prof
383	9	157	5,7	enviro	Prof
384	1	33	3,0	enviro	Prof
387	1	18	5,6	enviro	Prof
388	5	78	6,4	enviro	Prof
389	11	76	14,5	enviro	Prof
390	14	135	10,4	enviro	Prof
391	4	21	19,0	enviro	Prof
392	1	16	6,3	enviro	Prof
393	3	23	13,0	enviro	Prof
394	24	112	21,4	enviro	Prof
395	3	10	30,0	enviro	Prof
397	25	192	13,0	enviro	Prof
398	3	72	4,2	enviro	Prof
399	29	454	6,4	enviro	Prof
400	4	55	7,3	enviro	Prof
401	7	23	30,4	enviro	Prof
402	67	166	40,4	enviro	Prof
404	10	103	9,7	enviro	Prof
406	2	61	3,3	enviro	Prof
424	1	3	33,3	Phil	Post doc
427	1	4	25,0	Phil	Post doc
432	1	18	5,6	Phil	Post doc
434	8	14	57,1	Phil	Post doc
439	1	11	9,1	Phil	Assis Prof
446	5	13	38,5	Phil	Assis Prof
450	5	6	83,3	Phil	Assis Prof
451	1	9	11,1	Phil	Assis Prof
454	1	5	20,0	Phil	Assis Prof
455	2	10	20,0	Phil	Assis Prof
459	2	20	10,0	Phil	Assis Prof
460	5	111	4,5	Phil	Assis Prof
462	1	10	10,0	Phil	Assis Prof

463	2	5	40,0	Phil	Assis Prof
465	5	6	83,3	Phil	Assis Prof
469	1	21	4,8	Phil	Assis Prof
479	1	4	25,0	Phil	Assis Prof
482	1	39	2,6	Phil	Assis Prof
484	1	4	25,0	Phil	Assis Prof
486	2	8	25,0	Phil	Assis Prof
487	2	7	28,6	Phil	Assis Prof
495	1	4	25,0	Phil	assoc
500	1	33	3,0	Phil	assoc
502	1	9	11,1	Phil	assoc
520	1	7	14,3	Phil	assoc
523	2	37	5,4	Phil	assoc
525	1	12	8,3	Phil	assoc
528	1	14	7,1	Phil	assoc
544	6	28	21,4	Phil	assoc
548	1	29	3,4	Phil	assoc
554	1	9	11,1	Phil	assoc
555	4	12	33,3	Phil	assoc
560	3	42	7,1	Phil	assoc
562	2	6	33,3	Phil	assoc
570	1	3	33,3	Phil	Prof
571	1	48	2,1	Phil	Prof
574	3	59	5,1	Phil	Prof
575	7	16	43,8	Phil	Prof
576	1	16	6,3	Phil	Prof
577	1	36	2,8	Phil	Prof
580	6	125	4,8	Phil	Prof
581	4	32	12,5	Phil	Prof
582	3	24	12,5	Phil	Prof
585	1	4	25,0	Phil	Prof
586	22	79	27,8	Phil	Prof
588	1	10	10,0	Phil	Prof
590	1	54	1,9	Phil	Prof
591	5	28	17,9	Phil	Prof
592	8	86	9,3	Phil	Prof
600	2	44	4,5	Phil	Prof
601	4	14	28,6	Phil	Prof
602	4	30	13,3	Phil	Prof
604	2	18	11,1	Phil	Prof
606	6	25	24,0	Phil	Prof
612	2	22	9,1	Phil	Prof
615	8	121	6,6	Phil	Prof
617	4	33	12,1	Phil	Prof
620	2	29	6,9	Phil	Prof
626	7	25	28,0	Phil	Prof
629	1	34	2,9	Phil	Prof
630	1	120	0,8	Phil	Prof
631	1	65	1,5	Phil	Prof
633	2	39	5,1	Phil	Prof
636	1	10	10,0	Phil	Prof
639	1	22	4,5	Phil	Prof
642	6	23	26,1	Phil	Prof

645	1	16	6,3	Phil	Prof
648	2	28	7,1	Phil	Prof
649	1	34	2,9	Phil	Prof
650	3	64	4,7	Phil	Prof
653	3	14	21,4	Phil	Prof
654	58	173	33,5	Phil	Prof
655	2	55	3,6	Phil	Prof
656	1	14	7,1	Phil	Prof
693	1	156	0,6	Pub Health	Assis Prof
705	1	15	6,7	Pub Health	Assis Prof
706	2	290	0,7	Pub Health	Assis Prof
708	3	16	18,8	Pub Health	Assis Prof
709	3	20	15,0	Pub Health	Assis Prof
714	1	60	1,7	Pub Health	Assoc
723	7	36	19,4	Pub Health	Assoc
724	2	36	5,6	Pub Health	Assoc
738	2	8	25,0	Pub Health	Assoc
746	2	49	4,1	Pub Health	Assoc
747	1	23	4,3	Pub Health	Assoc
748	1	147	0,7	Pub Health	Assoc
752	2	117	1,7	Pub Health	Assoc
756	3	13	23,1	Pub Health	Assoc
758	3	106	2,8	Pub Health	Assoc
760	3	77	3,9	Pub Health	Assoc
764	1	63	1,6	Pub Health	Prof
765	3	39	7,7	Pub Health	Prof
766	8	669	1,2	Pub Health	Prof
769	29	119	24,4	Pub Health	Prof
771	3	224	1,3	Pub Health	Prof
776	3	187	1,6	Pub Health	Prof
778	1	40	2,5	Pub Health	Prof
781	5	118	4,2	Pub Health	Prof
784	2	235	0,9	Pub Health	Prof
787	1	47	2,1	Pub Health	Prof
789	1	23	4,3	Pub Health	Prof
791	2	9	22,2	Pub Health	Prof
792	1	66	1,5	Pub Health	Prof
793	2	128	1,6	Pub Health	Prof

## Appendix 2: Calculation of indicators

ID	Type	Indicator	Indicator	Calculation
<b>Productivity metrics</b>				
1	Publication	P	Publication count	Sum of total publications
2	Publication	Fp	Fractionalized publication count	Each publication divided by number of authors, limited to max. 10 authors
3	Publication	App	Average papers per author	Average number of author per paper over all publications
4	Publication/time	Pyrs	Years since first publication	Length of publication career from 1 <sup>st</sup> article in dataset to 2013
<b>Impact metrics</b>				
5	Citation	C	Citation count	Sum of total citations
6	Citations	minC	Minimum number of citations	Smallest number of citations to a paper over all papers
7	Citation	C-sc	Citation count minus self-citations.	Total citations minus self citations. Self citations calculated by CWTS.
8	Citation	Sig	Highest cited paper	Highest cited paper
9	Citation	%sc	Percent self-citations	Number of self citations calculated by CWTS, as a percent of total citations
10	Citation/author	Fc	Fractional citation count	Citations divided by authors. Limited to max. 10 authors
11	Citation/time	C<5	Citations less than 5 years old	Number of citations less than 5 years old, from the publication of the paper. Publication year is Zero
<b>Hybrid metrics</b>				
12	Citation/publication/field	IQP	Index of Quality & Productivity	a) $A = (mnjs \times Pyrs \times p + 1) / 2$ . (number of citations if author was of average quality for field) b) $A / \text{number of papers}$ (estimated performance per paper) c) define actual number of citations d) $IQP = \text{actual citations} / b + \text{number of papers}$ e) calculate field impact per paper $\times$ number of papers IQP= expected average performance of scholar in the field, amount of papers that are cited more frequently than average and how much more than average they are cited ( $Tc > a$ )
13	Citation/publication/field	Tc>a	(part of IQP)	As above-
14	Citation/publication/field	H norm	Normalized h	Define how many articles are included in the h-index and subtract these from total number of publications
15	Citation/publication	Cage	Age of citation	Average age of citations to all publications
16	Citation/publication	%PNC	Percent not cited	Total not cited papers divided by all papers, multiplied by 100.
17	Citation/publication	CPP	Citations per paper	Citations/papers
18	Citation/publication	h	h index	Publications are ranked in descending order after number of citations. Where number of citations and rank is the same, this is the h index
19	Citation/publication	g	g index	Publications are ranked in descending order after number of citations. The cumulative sum of citations is calculated, and where the square root of the cumulative sum is equal to the rank this is g-index
20	Citation/publication	m	m index	Median citations to publications included in h
21	Citation/publication	e	e index	Define total citations to articles in h-index. Subtract $h^2$ from total citations, giving $e^2$ . Square root of $e^2$ is e.

ID	Type	Indicator	Indicator	Calculation
23	Citation/publication	hg	Hg index	The square root of the sum of h multiplied by g.
24	Citation/publication	H <sup>2</sup>	Kosmulski index	Cube root of total citations
25	Citation/publication	A	A index	Average number of citations to articles in the h-index
26	Citation/publication	R	R index	Square root of the A-index
27	Citation/publication	AR	AR-index	Square root of average number of citations to articles in h-index
28	Citation/publication	h	Miller's h	Square root of half the number of total citations to all publications
29	Citation/publication	Q <sup>2</sup>	Quantitative & Quality index	Square root of (Geometric mean of h multiplied by median number of citations to papers in h index)
30	Citation/publication/author	hi	individual h	H index divided median number of researcher in papers included in h
31	Citation/publication/author	POP h	Harzing's publish or perish h index	Divide the number of total citations by number of authors for each paper. Calculate h using this normalized citation count
32	Citation/publication/author/time	AWCR	age weighted citation rate	(Citations/Pyrs)/Papers
33	Citation/publication/author/time	AW	Age weighted h	Square root of AWCR
34	Citation/publication/author/time	AWCRpa	Per-author AWCR	(citations/Pyrs)/average number of authors per paper
35	Citation/publication /time	M quotient	m-quotient	H divided by years since first publication
36	Citation/publication/time	Mg	Mg-quotient	G divided by years since first publication
37	Citation/publication/time	PI	Price Index	Citations<5 yrs old/total number citations. Publication year is Zero
<b>Journal-field benchmarks, calculated by CWTS</b>				
38		mcs	Mean citation score	Mean citation score of articles in publishing journal?
39		mncs	Mean normalized citation score.	Relates article to world average in regards to document type, publication year and field. 0.9 means cited 10% below average, 1.2% cited 20% above.
40		pp top n cites	Proportion of top papers	Proportion papers that receive more than 10 citations. 1 is that the paper has more than 10 citations and 0 that is has less
41		pp top prop	Proportion in top 10% of world	Proportion of papers in the top 10% of the world. 100% means that the article belongs to this set of papers, 0 means not.
42		pp uncited	Proportion uncited	Proportion uncited
43		mjs mcs	Average number of citations for the journal	This is the MCS (mean citation score) of the publishing journal, ie the average number of citations of the journal
44		mnjs	Mean normalized journal score	
45		mjs pp top n cits		Proportion of papers from the publishing journal that have more than 10 citations
46		mnjs pp top prop		Proportion of papers of the publishing journal that are on the pp top prop of the world.
47		mjs pp uncited		Proportion of papers of publishing journal that are not cited
48		prop self cits	Proportion self-citations	Proportion of self citations to external citations
49		int coverage	Internal coverage.	The proportion of the cited references of the paper covered by WOS
50	Author/article	pp collaboration	collaboration	Percentage inter-institutional collaboration
51		pp int collab	International/internal	Percentage
52		n self cites	Number of self-citations	Number of self-citations (author level)

## Appendix 3: Correlation matrix Astronomy

Indicator	Pyrs	App	CPP	Cites	Sum_of_self_cites	percent_sc	Cage	AWCR_C	AWCR_pp	AWCR_au	AW_	P	fp	mcC	percent_nc	Sig	millers_h	Fc	PI	Sum_af_pp_top_n_cits	Sum_pp_top_prop	average_mjs_mcs	Min_af_mjs_mcs	Maks_af_mjs_mcs	Gennemsnit_af_Mnjs	h	m_quotient	h_norm	m_	A_	R_	g	hg_	WU	mg_quotient	e	Q2	h2	AR	POP_h	IQP	nproductivity_adjusted_papers	times_cited_more_frequently_than_average_paper_	
Pyrs	1,00	-0,15	0,19	0,40	0,34	-0,21	0,75	0,15	-0,34	0,23	0,15	0,47	0,58	0,40	0,50	-0,62	0,44	0,23	0,43	0,23	0,43	-0,22	0,44	-0,10	0,42	-0,15	-0,32	0,34	0,32	0,32	0,39	0,40	0,22	-0,16	0,35	0,39	0,40	0,32	0,50	0,20	0,59	-0,37		
App	-0,15	1,00	0,25	0,23	0,32	0,33	-0,20	0,35	0,32	0,08	0,35	0,17	-0,15	0,06	-0,12	0,22	0,23	-0,01	0,24	0,17	0,25	0,06	-0,06	0,20	0,16	0,22	0,41	-0,04	0,24	0,25	0,25	0,24	0,23	0,03	0,41	0,24	0,23	0,23	0,25	-0,06	0,27	0,02	0,31	
CPP	0,19	0,25	1,00	0,62	0,54	-0,19	0,23	0,64	0,48	0,60	0,64	0,37	0,23	0,06	-0,39	0,67	0,62	0,51	-0,14	0,59	0,64	0,45	0,07	0,41	0,36	0,58	0,46	0,07	0,68	0,75	0,75	0,67	0,62	0,06	0,53	0,71	0,64	0,62	0,75	0,53	0,90	0,18	0,39	
Cites	0,40	0,23	0,62	1,00	0,83	-0,11	0,33	0,75	0,20	0,72	0,75	0,76	0,53	0,38	-0,21	0,75	1,00	0,74	-0,28	0,87	0,73	0,45	-0,19	0,54	0,22	0,91	0,44	-0,26	0,81	0,81	0,81	0,96	0,95	0,13	0,44	0,86	0,90	1,00	0,81	0,70	0,70	0,51	0,14	
Sum_of_self_cites	0,34	0,32	0,54	0,83	1,00	0,06	0,25	0,74	0,19	0,63	0,74	0,76	0,48	0,41	-0,19	0,67	0,83	0,62	-0,20	0,75	0,65	0,37	-0,23	0,52	0,17	0,83	0,47	-0,29	0,72	0,72	0,72	0,82	0,83	0,12	0,46	0,76	0,80	0,83	0,72	0,57	0,62	0,49	0,15	
percent_sc	-0,21	0,33	-0,19	-0,11	0,06	1,00	-0,28	-0,04	-0,04	-0,18	-0,04	-0,03	-0,18	0,04	0,13	-0,14	-0,11	-0,25	0,29	-0,18	-0,15	-0,26	-0,13	-0,08	-0,16	-0,10	0,05	-0,08	-0,12	-0,14	-0,14	-0,13	-0,11	0,00	0,02	-0,14	-0,12	-0,11	-0,14	-0,31	-0,15	-0,07	0,02	
Cage	0,75	-0,20	0,23	0,33	0,25	-0,28	1,00	0,11	-0,24	0,22	0,11	0,34	0,48	0,26	-0,05	0,28	0,33	0,45	-0,66	0,38	0,17	0,50	-0,12	0,39	-0,04	0,34	-0,16	-0,17	0,31	0,28	0,28	0,32	0,33	0,22	-0,16	0,30	0,33	0,33	0,28	0,47	0,21	0,44	-0,28	
AWCR_C	0,15	0,35	0,64	0,75	0,74	-0,04	0,11	1,00	0,41	0,73	1,00	0,59	0,36	0,26	-0,27	0,69	0,75	0,56	-0,08	0,69	0,76	0,32	-0,12	0,42	0,30	0,73	0,68	-0,16	0,72	0,75	0,75	0,77	0,75	0,07	0,69	0,77	0,74	0,75	0,75	0,54	0,74	0,33	0,35	
AWCR_pp	-0,34	0,32	0,48	0,20	0,19	-0,04	-0,24	0,41	1,00	0,31	0,41	0,00	-0,17	-0,24	-0,38	0,28	0,20	0,07	0,26	0,16	0,33	0,08	0,24	0,04	0,38	0,17	0,57	0,31	0,27	0,31	0,31	0,24	0,20	-0,08	0,66	0,28	0,22	0,20	0,31	0,09	0,46	-0,23	0,79	
AWCR_au	0,23	0,08	0,60	0,72	0,63	-0,18	0,22	0,73	0,31	1,00	0,73	0,58	0,51	0,28	-0,25	0,65	0,72	0,71	-0,19	0,69	0,70	0,35	-0,11	0,38	0,26	0,69	0,52	-0,16	0,67	0,70	0,70	0,73	0,71	0,07	0,53	0,71	0,70	0,72	0,70	0,70	0,66	0,36	0,25	
AW_	0,15	0,35	0,64	0,75	0,74	-0,04	0,11	1,00	0,41	0,73	1,00	0,59	0,36	0,26	-0,27	0,69	0,75	0,56	-0,08	0,69	0,76	0,32	-0,12	0,42	0,30	0,73	0,68	-0,16	0,72	0,75	0,75	0,77	0,75	0,07	0,69	0,77	0,74	0,75	0,75	0,54	0,74	0,33	0,35	
P	0,47	0,17	0,37	0,76	0,76	-0,03	0,34	0,59	0,00	0,58	0,59	1,00	0,67	0,56	-0,08	0,57	0,76	0,69	-0,30	0,75	0,58	0,37	-0,33	0,52	0,09	0,78	0,33	-0,48	0,62	0,59	0,59	0,72	0,75	0,16	0,30	0,64	0,71	0,76	0,59	0,62	0,46	0,69	-0,04	
fp	0,58	-0,15	0,23	0,53	0,48	-0,18	0,48	0,36	-0,17	0,51	0,36	0,67	1,00	0,51	-0,01	0,42	0,53	0,71	-0,45	0,57	0,40	0,34	-0,29	0,40	0,00	0,55	0,12	-0,46	0,44	0,43	0,43	0,51	0,53	0,16	0,09	0,46	0,51	0,53	0,43	0,67	0,29	0,66	-0,20	
nnC	0,40	0,06	0,06	0,38	0,41	0,04	0,26	0,26	-0,24	0,28	0,26	0,56	0,51	1,00	0,39	0,28	0,38	0,39	-0,29	0,38	0,26	0,19	-0,45	0,34	-0,09	0,41	0,09	-0,56	0,30	0,27	0,27	0,36	0,38	0,10	0,05	0,30	0,36	0,38	0,27	0,35	0,13	0,57	-0,24	
percent_nc	0,05	-0,12	-0,39	-0,21	-0,19	0,13	-0,05	-0,27	-0,38	-0,25	-0,27	-0,08	-0,01	0,39	1,00	-0,23	-0,21	-0,17	-0,05	-0,21	-0,27	-0,16	-0,25	-0,10	-0,25	-0,19	-0,25	-0,19	-0,24	-0,27	-0,27	-0,23	-0,21	-0,01	-0,29	-0,25	-0,25	-0,22	-0,21	-0,27	-0,18	-0,36	0,05	-0,34
Sig	0,33	0,22	0,67	0,75	0,67	-0,14	0,28	0,69	0,28	0,65	0,69	0,57	0,42	0,28	-0,23	1,00	0,75	0,62	-0,25	0,67	0,66	0,42	-0,10	0,49	0,23	0,67	0,40	-0,17	0,69	0,84	0,84	0,77	0,72	0,14	0,46	0,83	0,70	0,75	0,84	0,59	0,73	0,36	0,22	
millers_h	0,40	0,23	0,62	1,00	0,83	-0,11	0,33	0,75	0,20	0,72	0,75	0,76	0,53	0,38	-0,21	0,75	1,00	0,74	-0,28	0,87	0,73	0,45	-0,19	0,54	0,22	0,91	0,44	-0,26	0,81	0,81	0,81	0,96	0,95	0,13	0,44	0,86	0,90	1,00	0,81	0,70	0,70	0,51	0,14	
Fc	0,50	-0,01	0,51	0,74	0,62	-0,25	0,45	0,56	0,07	0,71	0,56	0,69	0,71	0,39	-0,17	0,62	0,74	1,00	-0,40	0,78	0,61	0,46	-0,18	0,47	0,16	0,75	0,29	-0,27	0,67	0,66	0,66	0,74	0,74	0,13	0,29	0,69	0,73	0,74	0,66	0,88	0,55	0,56	0,02	
PI	-0,62	0,24	-0,14	-0,28	-0,20	0,29	-0,66	-0,08	0,26	-0,19	-0,08	-0,30	-0,45	-0,29	-0,05	-0,25	-0,28	-0,40	1,00	-0,31	-0,14	-0,36	0,16	-0,30	0,07	-0,28	0,17	0,20	-0,23	-0,23	-0,23	-0,27	-0,27	-0,16	0,16	-0,25	-0,26	-0,28	-0,23	-0,42	-0,14	-0,39	0,29	
Sum_af_pp_top_n_cits	0,44	0,17	0,59	0,87	0,75	-0,18	0,38	0,69	0,16	0,69	0,69	0,75	0,57	0,38	-0,21	0,67	0,87	0,78	-0,31	1,00	0,70	0,50	-0,18	0,55	0,23	0,89	0,40	-0,25	0,78	0,74	0,74	0,86	0,88	0,15	0,39	0,79	0,87	0,87	0,74	0,75	0,65	0,55	0,09	
Sum_pp_top_prop	0,23	0,25	0,64	0,73	0,65	-0,15	0,17	0,76	0,33	0,70	0,76	0,58	0,40	0,26	-0,27	0,66	0,73	0,61	-0,14	0,70	1,00	0,36	-0,10	0,41	0,30	0,70	0,54	-0,15	0,71	0,74	0,74	0,75	0,72	0,07	0,56	0,75	0,72	0,73	0,74	0,59	0,70	0,37	0,26	
average_mjs_mcs	0,43	0,06	0,45	0,45	0,37	-0,26	0,50	0,32	0,08	0,35	0,32	0,37	0,34	0,19	-0,16	0,42	0,45	0,46	-0,36	0,50	0,36	1,00	0,00	0,61	0,39	0,46	0,12	-0,02	0,47	0,45	0,45	0,47	0,46	0,17	0,14	0,46	0,47	0,45	0,45	0,47	0,41	0,42	-0,06	
Min_af_mjs_mcs	-0,22	-0,06	0,07	-0,19	-0,23	-0,13	-0,12	-0,12	0,24	-0,11	-0,12	-0,33	-0,29	-0,45	-0,25	-0,10	-0,19	-0,18	0,16	-0,18	-0,10	0,00	1,00	-0,13	0,25	-0,21	-0,04	0,40	-0,13	-0,10	-0,10	-0,16	-0,19	-0,05	0,00	-0,12	-0,17	-0,19	-0,10	-0,16	0,00	-0,30	0,18	
Maks_af_mjs_mcs	0,44	0,20	0,41	0,54	0,52	-0,08	0,39	0,42	0,04	0,38	0,42	0,52	0,40	0,34	-0,10	0,49	0,54	0,47	-0,30	0,55	0,41	0,61	-0,13	1,00	0,30	0,54	0,20	-0,21	0,52	0,51	0,51	0,54	0,54	0,17	0,21	0,53	0,55	0,54	0,51	0,44	0,42	0,54	-0,07	
Gennemsnit_af_Mnjs	-0,10	0,16	0,36	0,22	0,17	-0,16	-0,04	0,30	0,38	0,26	0,30	0,59	0,00	-0,09	-0,25	0,23	0,22	0,16	0,07	0,23	0,30	0,39	0,25	0,30	1,00	0,22	0,32	0,18	0,26	0,27	0,27	0,24	0,23	0,00	0,34	0,26	0,24	0,22	0,27	0,16	0,31	0,11	0,17	
h	0,42	0,22	0,58	0,91	0,83	-0,10	0,34	0,73	0,17	0,69	0,73	0,78	0,55	0,41	-0,19	0,67	0,91	0,75	-0,28	0,89	0,70	0,46	-0,21	0,54	0,22	1,00	0,45	-0,26	0,78	0,74	0,74	0,89	0,95	0,13	0,43	0,79	0,90	0,91	0,74	0,71	0,66	0,55	0,11	
m_quotient	-0,15	0,41	0,46	0,44	0,47	0,05	-0,16	0,68	0,57	0,52	0,68	0,33	0,12	0,09	-0,25	0,40	0,44	0,29	0,17	0,40	0,54	0,12	-0,04	0,20	0,32	0,45	1,00	-0,01	0,45	0,45	0,45	0,46	0,45	-0,03	0,84	0,46	0,46	0,44	0,45	0,28	0,52	0,09	0,52	
h_norm	-0,32	-0,04	0,07	-0,26	-0,29	-0,08	-0,17	-0,16	0,31	-0,16	-0,16	-0,48	-0,46	-0,56	-0,19	-0,17	-0,26	-0,27	0,20	-0,25	-0,15	-0,02	0,40	-0,21	0,18	-0,26	-0,01	1,00	-0,15	-0,15	-0,15	-0,22	-0,23	-0,14	0,01	-0,17	-0,20	-0,26	-0,15	-0,20	0,00	-0,53	0,30	
m_	0,34	0,24	0,68	0,81	0,72	-0,12	0,31	0,72	0,27	0,67	0,72	0,62	0,44	0,30	-0,24	0,69	0,81	0,67	-0,23	0,78	0,71	0,47	-0,13	0,52	0,26	0,78	0,45	-0,15	1,00	0,82	0,82	0,84	0,81	0,10	0,47	0,84	0,88	0,81	0,82	0,66	0,74	0,41	0,21	
A_	0,32	0,25	0,75	0,81	0,72	-0,14	0,28	0,75	0,31	0,70	0,75	0,59	0,43	0,27	-0,27	0,84	0,81	0,66	-0,23	0,74	0,74	0,45	-0,10	0,51	0,27	0,74	0,45	-0,15	0,82	1,00	0,86	0,79	0,11	0,51	0,94	0,80	0,81	1,00	0,64	0,81	0,37			

## Appendix 4: Correlation matrix *Environmental Science*

Indicator	Pyrs	App	CPP	Cites	Sum_of_self_cites	percent_sc	P	fp	nnC	percent_nc	AWCR_au	cage	AWCR_C	AWCR_pp	AW_	Sig	sumcits	sumcits2	millers_h	Fc	PI	Sum_af_pp_top_n_cits	Sum_pp_top_prop	average_mjs_mcs	Min_af_mjs_mcs	Maks_af_mjs_mcs	Gennemsnit_af_Mnjs	IQP	nproductivity_adjusted_papers	times_cited_more_frequently_than_average_paper_	h	m_quotient	h_norm	m_	A_	R_	g	hg_	WU	mg_quotient	e	Q2	h2	AR	POP_h
Pyrs	1,00	0,01	0,32	0,50	0,47	-0,05	0,55	0,56	0,36	-0,20	0,27	0,68	0,28	-0,26	0,28	0,42	0,50	0,50	0,50	0,51	-0,57	0,48	0,36	0,39	-0,11	0,46	0,06	0,33	0,59	-0,34	0,50	-0,08	-0,24	0,39	0,42	0,42	0,48	0,49	0,15	-0,07	0,43	0,46	0,50	-0,08	0,48
App	0,01	1,00	0,15	0,16	0,17	0,08	0,12	-0,08	0,05	-0,06	0,01	-0,02	0,19	0,14	0,19	0,18	0,16	0,16	0,16	0,02	-0,02	0,16	0,13	0,11	0,02	0,15	0,07	0,19	0,04	0,13	0,16	0,18	0,03	0,18	0,18	0,16	0,16	0,00	0,18	0,17	0,17	0,16	0,02	0,04	
CPP	0,32	0,15	1,00	0,66	0,54	-0,21	0,42	0,37	0,12	-0,42	0,62	0,40	0,67	0,43	0,67	0,75	0,66	0,66	0,66	0,61	-0,37	0,68	0,60	0,59	0,12	0,51	0,32	0,86	0,22	0,28	0,63	0,39	0,14	0,73	0,78	0,78	0,71	0,66	0,04	0,50	0,76	0,69	0,66	0,02	0,67
Cites	0,50	0,16	0,66	1,00	0,81	-0,05	0,77	0,66	0,40	-0,34	0,73	0,47	0,79	0,17	0,79	0,76	1,00	1,00	1,00	0,85	-0,44	0,86	0,71	0,53	-0,06	0,64	0,24	0,75	0,51	0,06	0,91	0,41	-0,14	0,76	0,79	0,95	0,95	0,07	0,43	0,83	0,90	1,00	-0,04	0,84	
Sum_of_self_cites	0,47	0,17	0,54	0,81	1,00	0,15	0,78	0,66	0,45	-0,30	0,66	0,42	0,72	0,12	0,72	0,64	0,81	0,81	0,81	0,74	-0,39	0,72	0,63	0,44	-0,11	0,58	0,20	0,64	0,52	0,02	0,83	0,41	-0,19	0,65	0,65	0,65	0,78	0,81	0,09	0,40	0,69	0,77	0,81	-0,03	0,74
percent_sc	-0,05	0,08	-0,21	-0,05	0,15	1,00	0,06	0,04	0,13	0,11	-0,06	-0,12	-0,03	-0,16	-0,03	-0,15	-0,05	-0,05	-0,05	-0,06	0,10	-0,13	-0,10	-0,19	-0,15	-0,07	-0,10	-0,14	0,08	-0,11	-0,01	0,05	-0,14	-0,15	-0,16	-0,16	-0,08	-0,05	0,08	-0,05	-0,13	-0,07	-0,05	0,06	-0,09
P	0,55	0,12	0,42	0,77	0,78	0,06	1,00	0,78	0,58	-0,23	0,59	0,45	0,63	-0,03	0,63	0,57	0,77	0,77	0,77	0,73	-0,41	0,70	0,60	0,40	-0,16	0,58	0,15	0,53	0,66	-0,11	0,79	0,32	-0,36	0,58	0,58	0,58	0,72	0,75	0,08	0,30	0,62	0,71	0,77	-0,08	0,70
fp	0,56	-0,08	0,37	0,66	0,66	0,04	0,78	1,00	0,53	-0,20	0,58	0,46	0,54	-0,07	0,54	0,50	0,66	0,66	0,66	0,74	-0,39	0,61	0,55	0,35	-0,17	0,51	0,10	0,46	0,64	-0,15	0,68	0,24	-0,35	0,50	0,51	0,51	0,63	0,65	0,06	0,22	0,55	0,61	0,66	-0,10	0,69
nnC	0,36	0,05	0,12	0,40	0,45	0,13	0,58	0,53	1,00	0,23	0,32	0,18	0,34	-0,18	0,34	0,29	0,40	0,40	0,40	0,39	-0,23	0,37	0,31	0,16	-0,28	0,36	0,00	0,22	0,51	-0,21	0,42	0,15	-0,47	0,31	0,30	0,30	0,38	0,40	0,11	0,13	0,33	0,38	0,40	-0,13	0,38
percent_nc	-0,20	-0,06	-0,42	-0,34	-0,30	0,11	-0,23	-0,20	0,23	1,00	-0,31	-0,35	-0,32	-0,26	-0,32	-0,34	-0,34	-0,34	-0,34	-0,33	0,20	-0,33	-0,33	-0,34	-0,18	-0,24	-0,24	-0,38	-0,12	-0,17	-0,35	-0,22	-0,08	-0,30	-0,31	-0,31	-0,34	-0,34	0,04	-0,22	-0,32	-0,33	-0,34	-0,02	-0,34
AWCR_au	0,27	0,01	0,62	0,73	0,66	-0,06	0,59	0,58	0,32	-0,31	1,00	0,30	0,82	0,34	0,82	0,66	0,73	0,73	0,73	0,75	-0,28	0,70	0,68	0,44	-0,03	0,50	0,27	0,72	0,34	0,22	0,71	0,57	-0,07	0,67	0,68	0,68	0,74	0,73	0,01	0,60	0,71	0,72	0,73	-0,02	0,79
cage	0,68	-0,02	0,40	0,47	0,42	-0,12	0,45	0,46	0,18	-0,35	0,30	1,00	0,29	-0,10	0,29	0,43	0,47	0,47	0,47	0,49	-0,63	0,47	0,32	0,48	-0,01	0,47	0,08	0,38	0,42	-0,17	0,48	-0,02	-0,09	0,39	0,41	0,41	0,46	0,47	0,06	0,00	0,42	0,44	0,47	-0,06	0,47
AWCR_C	0,28	0,19	0,67	0,79	0,72	-0,03	0,63	0,54	0,34	-0,32	0,82	0,29	1,00	0,35	1,00	0,72	0,79	0,79	0,79	0,71	-0,29	0,75	0,71	0,46	-0,04	0,54	0,28	0,79	0,36	0,23	0,77	0,61	-0,06	0,73	0,74	0,74	0,80	0,79	0,02	0,65	0,77	0,79	0,79	-0,02	0,75
AWCR_pp	-0,26	0,14	0,43	0,17	0,12	-0,16	-0,03	-0,07	-0,18	-0,26	0,34	-0,10	0,35	1,00	0,35	0,27	0,17	0,17	0,17	0,14	0,10	0,20	0,25	0,20	0,23	0,09	0,31	0,39	-0,24	0,69	0,15	0,55	0,37	0,29	0,29	0,29	0,21	0,18	-0,10	0,65	0,27	0,21	0,17	0,06	0,20
AW_	0,28	0,19	0,67	0,79	0,72	-0,03	0,63	0,54	0,34	-0,32	0,82	0,29	1,00	0,35	1,00	0,72	0,79	0,79	0,79	0,71	-0,29	0,75	0,71	0,46	-0,04	0,54	0,28	0,79	0,36	0,23	0,77	0,61	-0,06	0,73	0,74	0,74	0,80	0,79	0,02	0,65	0,77	0,79	0,79	-0,02	0,75
Sig	0,42	0,18	0,75	0,76	0,64	-0,15	0,57	0,50	0,29	-0,32	0,66	0,43	0,72	0,27	0,72	1,00	0,76	0,76	0,76	0,70	-0,43	0,73	0,66	0,53	0,00	0,58	0,24	0,80	0,36	0,16	0,70	0,37	-0,02	0,74	0,87	0,87	0,81	0,75	0,07	0,46	0,87	0,75	0,76	-0,02	0,72
sumcits	0,50	0,16	0,66	1,00	0,81	-0,05	0,77	0,66	0,40	-0,34	0,73	0,47	0,79	0,17	0,79	0,76	1,00	1,00	1,00	0,85	-0,44	0,86	0,71	0,53	-0,06	0,64	0,24	0,75	0,51	0,06	0,91	0,41	-0,14	0,76	0,79	0,95	0,95	0,07	0,43	0,83	0,90	1,00	-0,04	0,84	
sumcits2	0,50	0,16	0,66	1,00	0,81	-0,05	0,77	0,66	0,40	-0,34	0,73	0,47	0,79	0,17	0,79	0,76	1,00	1,00	1,00	0,85	-0,44	0,86	0,71	0,53	-0,06	0,64	0,24	0,75	0,51	0,06	0,91	0,41	-0,14	0,76	0,79	0,95	0,95	0,07	0,43	0,83	0,90	1,00	-0,04	0,84	
millers_h	0,50	0,16	0,66	1,00	0,81	-0,05	0,77	0,66	0,40	-0,34	0,73	0,47	0,79	0,17	0,79	0,76	1,00	1,00	1,00	0,85	-0,44	0,86	0,71	0,53	-0,06	0,64	0,24	0,75	0,51	0,06	0,91	0,41	-0,14	0,76	0,79	0,95	0,95	0,07	0,43	0,83	0,90	1,00	-0,04	0,84	
Fc	0,51	0,02	0,61	0,85	0,74	-0,06	0,73	0,74	0,39	-0,33	0,75	0,49	0,71	0,14	0,71	0,70	0,85	0,85	0,85	1,00	-0,46	0,79	0,68	0,51	-0,06	0,61	0,22	0,69	0,51	0,03	0,83	0,37	-0,15	0,71	0,73	0,73	0,84	0,84	0,06	0,39	0,76	0,82	0,85	-0,06	0,89
PI	-0,57	-0,02	-0,37	-0,44	-0,39	0,10	-0,41	-0,39	-0,23	0,20	-0,28	-0,63	-0,29	0,10	-0,29	-0,43	-0,44	-0,44	-0,44	-0,46	1,00	-0,44	-0,32	-0,42	0,05	-0,44	-0,08	-0,36	-0,39	0,17	-0,44	0,00	0,12	-0,41	-0,42	-0,42	-0,44	-0,44	-0,12	-0,03	-0,43	-0,43	-0,44	0,05	-0,44
Sum_af_pp_top_n_cits	0,48	0,16	0,68	0,86	0,72	-0,13	0,70	0,61	0,37	-0,33	0,70	0,47	0,75	0,20	0,75	0,73	0,86	0,86	0,86	0,79	-0,44	1,00	0,70	0,57	-0,02	0,63	0,27	0,75	0,49	0,07	0,86	0,42	-0,09	0,80	0,78	0,78	0,87	0,87	0,08	0,44	0,82	0,87	0,86	-0,04	0,83
Sum_pp_top_prop	0,36	0,13	0,60	0,71	0,63	-0,10	0,60	0,55	0,31	-0,33	0,68	0,32	0,71	0,25	0,71	0,66	0,71	0,71	0,71	0,68	-0,32	0,70	1,00	0,38	-0,04	0,46	0,24	0,67	0,39	0,14	0,70	0,44	-0,10	0,67	0,69	0,69	0,73	0,71	0,06	0,48	0,70	0,71	0,71	-0,03	0,72
average_mjs_mcs	0,39	0,11	0,59	0,53	0,44	-0,19	0,40	0,35	0,16	-0,34	0,44	0,48	0,46	0,20	0,46	0,53	0,53	0,53	0,53	0,51	-0,42	0,57	0,38	1,00	0,19	0,66	0,48	0,53	0,38	-0,01	0,53	0,23	0,08	0,55	0,55	0,55	0,56	0,54	0,06	0,27	0,55	0,55	0,53	-0,04	0,55
Min_af_mjs_mcs	-0,11	0,02	0,12	-0,06	-0,11	-0,15	-0,16	-0,17	-0,28	-0,18	-0,03	-0,01	-0,04	0,23	-0,04	0,00	-0,06	-0,06	-0,06	-0,06	0,05	-0,02	-0,04	0,19	1,00	-0,02	0,27	0,04	-0,12	0,12	-0,07	0,01	0,28	0,03	0,01	0,01	-0,04	-0,05	0,01	0,04	-0,01	-0,03	-0,06	0,09	-0,04
Maks_af_mjs_mcs	0,46	0,15	0,51	0,64	0,58	-0,07	0,58	0,51	0,36	-0,24	0,50	0,47	0,54	0,09	0,54	0,58	0,64	0,64	0,64	0,61	-0,44	0,63	0,46	0,66	-0,02	1,00	0,34	0,53	0,51	-0,07	0,63	0,27	-0,09	0,58	0,58	0,58	0,64	0,63	0,06	0,29	0,61	0,63	0,64	-0,04	0,62
Gennemsnit_af_Mnjs	0,06	0,07	0,32	0,24	0,20	-0,10	0,15	0,10	0,00	-0,24	0,27	0,08	0,28	0,31	0,28	0,24	0,24	0,24	0,24	0,22	-0,08	0,27	0,24	0,48	0,27	0,34	1,00	0,26	0,25	0,00	0,24	0,28	0,14	0,28	0,26	0,26	0,25	0,25	0,04	0,30	0,27	0,26	0,24	0,04	0,25
IQP	0,33	0,19	0,86	0,75	0,64	-0,14	0,53	0,46	0,22	-0,38	0,72	0,38	0,79	0,39	0,79	0,80	0,75	0,75	0,75	0,69	-0,36	0,75	0,67	0,53	0,04	0,53	0,26	1,00	0,28	0,28	0,72	0,49	0,07	0,78	0,83	0,83	0,81	0,76	0,03	0,57	0,83	0,78	0,75	0,00	0,75
nproductivity_adjusted_papers	0,59	0,04	0,22	0,51	0,52	0,08	0,66	0,64	0,51	-0,12	0,34	0,42	0,36	-0,24	0,36	0,36	0,51	0,51	0,51	0,51	-0,39	0,49	0,39	0,38	-0,12	0,51	0,25	0,28	1,00	-0,42	0,54														

## Appendix 5: Correlation matrix *Philosophy*

Indicator	Pys	App	CPP	Cites	Sum_of_self_cites	percent_sc	P	fp	nnC	percent_nc	Cage	AWCR_C	AWCR_pp	AWCR_au	AW_	Sig	millers_h	Fc	PI	Sum_af_pp_top_n_cits	Sum_pp_top_prop	average_mjs_mcs	Min_af_mjs_mcs	Maks_af_mjs_mcs	Gennemsnt_af_Mnjs	IQP	nproductivity_adjusted_papers	times_cited_more_frequently_than_average_paper_	h	m_quotient	h_norm	m_	A_	R_	g	hg_	WU	mg_quotient	e	Q2	h2	AR	Pop_h
Pys	1,00	0,15	0,21	0,39	0,34	0,00	0,52	0,53	0,49	-0,07	0,40	0,18	-0,08	0,19	0,18	0,34	0,39	0,41	-0,45	0,30	0,23	0,33	-0,03	0,39	0,08	0,20	0,45	-0,08	0,40	-0,10	-0,03	0,34	0,34	0,34	0,38	0,38	0,22	0,06	0,33	0,38	0,39	0,34	0,40
App	0,15	1,00	0,45	0,44	0,47	0,19	0,32	0,23	0,14	-0,33	0,26	0,46	0,39	0,37	0,46	0,45	0,44	0,38	-0,04	0,41	0,28	0,39	0,11	0,41	0,16	0,47	0,42	0,36	0,44	0,36	0,21	0,42	0,44	0,44	0,46	0,45	0,03	0,45	0,46	0,44	0,44	0,41	
CPP	0,21	0,45	1,00	0,74	0,60	0,01	0,39	0,34	0,11	-0,64	0,56	0,78	0,73	0,75	0,78	0,79	0,74	0,70	-0,11	0,61	0,52	0,55	0,18	0,56	0,36	0,88	-0,07	0,61	0,70	0,60	0,44	0,76	0,77	0,77	0,76	0,72	0,02	0,73	0,76	0,76	0,74	0,77	0,71
Cites	0,39	0,44	0,74	1,00	0,77	0,12	0,67	0,61	0,38	-0,47	0,53	0,81	0,51	0,80	0,81	0,88	1,00	0,94	-0,25	0,69	0,62	0,55	0,06	0,64	0,35	0,77	0,22	0,42	0,88	0,51	0,27	0,82	0,85	0,85	0,94	0,93	0,08	0,67	0,85	0,94	1,00	0,85	0,86
Sum_of_self_cites	0,34	0,47	0,60	0,77	1,00	0,39	0,66	0,59	0,39	-0,43	0,43	0,71	0,43	0,69	0,71	0,70	0,77	0,75	-0,14	0,63	0,56	0,44	-0,04	0,54	0,28	0,66	0,20	0,37	0,80	0,51	0,23	0,65	0,67	0,67	0,77	0,78	0,08	0,61	0,69	0,74	0,77	0,67	0,76
percent_sc	0,00	0,19	0,01	0,12	0,39	1,00	0,17	0,14	0,12	-0,01	-0,09	0,13	0,03	0,11	0,13	0,06	0,12	0,11	0,13	0,02	0,04	-0,08	-0,25	0,01	-0,06	0,08	0,03	0,04	0,17	0,14	-0,03	0,03	0,03	0,03	0,10	0,13	0,01	0,14	0,04	0,09	0,12	0,03	0,11
P	0,52	0,32	0,39	0,67	0,66	0,17	1,00	0,93	0,71	-0,21	0,34	0,53	0,19	0,53	0,53	0,58	0,67	0,68	-0,29	0,51	0,51	0,38	-0,08	0,49	0,22	0,46	0,49	0,30	-0,02	0,54	0,55	0,55	0,64	0,66	0,15	0,41	0,56	0,62	0,67	0,55	0,67		
fp	0,53	0,23	0,34	0,61	0,59	0,14	0,93	1,00	0,74	-0,16	0,32	0,47	0,14	0,49	0,47	0,53	0,61	0,64	-0,30	0,45	0,49	0,33	-0,11	0,44	0,21	0,40	0,51	0,09	0,63	0,25	-0,06	0,49	0,50	0,50	0,58	0,60	0,16	0,36	0,51	0,57	0,61	0,50	0,62
nnC	0,49	0,14	0,11	0,38	0,39	0,12	0,71	0,74	1,00	0,13	0,09	0,25	-0,06	0,27	0,25	0,33	0,38	0,40	-0,30	0,30	0,33	0,18	-0,21	0,27	0,09	0,18	0,53	-0,08	0,38	0,07	-0,27	0,31	0,31	0,31	0,37	0,37	0,15	0,18	0,32	0,35	0,38	0,31	0,39
percent_nc	-0,07	-0,33	-0,64	-0,47	-0,43	-0,01	-0,21	-0,16	0,13	1,00	-0,59	-0,53	-0,65	-0,50	-0,53	-0,46	-0,47	-0,45	-0,07	-0,34	-0,32	-0,37	-0,25	-0,37	-0,31	-0,59	0,19	-0,57	-0,51	-0,57	-0,52	-0,42	-0,43	-0,43	-0,46	-0,46	0,00	-0,50	-0,43	-0,45	-0,47	-0,43	-0,45
Cage	0,40	0,26	0,56	0,53	0,43	-0,09	0,34	0,32	0,09	-0,59	1,00	0,43	0,38	0,44	0,43	0,51	0,53	0,54	-0,25	0,40	0,33	0,44	0,17	0,47	0,25	0,51	0,05	0,35	0,55	0,30	0,37	0,48	0,49	0,49	0,52	0,51	0,11	0,34	0,49	0,51	0,53	0,49	0,52
AWCR_C	0,18	0,46	0,78	0,81	0,71	0,13	0,53	0,47	0,25	-0,53	0,43	1,00	0,67	0,92	1,00	0,81	0,81	0,77	-0,11	0,64	0,62	0,48	0,08	0,55	0,37	0,85	0,05	0,55	0,78	0,69	0,33	0,77	0,79	0,79	0,81	0,80	0,04	0,83	0,77	0,81	0,81	0,79	0,77
AWCR_pp	-0,08	0,39	0,73	0,51	0,43	0,03	0,19	0,14	-0,06	-0,65	0,38	0,67	1,00	0,65	0,67	0,57	0,51	0,48	0,11	0,44	0,40	0,38	0,20	0,37	0,33	0,70	-0,29	0,75	0,50	0,74	0,53	0,55	0,55	0,55	0,52	0,50	-0,04	0,74	0,53	0,52	0,51	0,55	0,50
AWCR_au	0,19	0,37	0,75	0,80	0,69	0,11	0,53	0,49	0,27	-0,50	0,44	0,92	0,65	1,00	0,92	0,79	0,80	0,79	-0,12	0,63	0,63	0,46	0,07	0,52	0,38	0,80	0,08	0,52	0,76	0,67	0,31	0,75	0,77	0,77	0,79	0,78	0,04	0,79	0,75	0,80	0,80	0,77	0,78
AW_	0,18	0,46	0,78	0,81	0,71	0,13	0,53	0,47	0,25	-0,53	0,43	1,00	0,67	0,92	1,00	0,81	0,81	0,77	-0,11	0,64	0,62	0,48	0,08	0,55	0,37	0,85	0,05	0,55	0,78	0,69	0,33	0,77	0,79	0,79	0,81	0,80	0,04	0,83	0,77	0,81	0,81	0,79	0,77
Sig	0,34	0,45	0,79	0,88	0,70	0,06	0,58	0,53	0,33	-0,46	0,51	0,81	0,57	0,79	0,81	1,00	0,88	0,84	-0,23	0,71	0,59	0,57	0,08	0,63	0,35	0,81	0,13	0,48	0,78	0,52	0,29	0,91	0,95	0,95	0,90	0,84	0,08	0,72	0,93	0,90	0,88	0,95	0,82
millers_h	0,39	0,44	0,74	1,00	0,77	0,12	0,67	0,61	0,38	-0,47	0,53	0,81	0,51	0,80	0,81	0,88	1,00	0,94	-0,25	0,69	0,62	0,55	0,06	0,64	0,35	0,77	0,22	0,42	0,88	0,51	0,27	0,82	0,85	0,85	0,94	0,93	0,08	0,67	0,85	0,94	1,00	0,85	0,86
Fc	0,41	0,38	0,70	0,94	0,75	0,11	0,68	0,64	0,40	-0,45	0,54	0,77	0,48	0,79	0,77	0,84	0,94	1,00	-0,27	0,67	0,63	0,53	0,05	0,61	0,35	0,73	0,25	0,39	0,87	0,49	0,24	0,79	0,81	0,81	0,89	0,89	0,09	0,64	0,81	0,90	0,94	0,81	0,87
PI	-0,45	-0,04	-0,11	-0,25	-0,14	0,13	-0,29	-0,30	-0,30	-0,07	-0,25	-0,11	0,11	-0,12	-0,11	-0,23	-0,25	-0,27	1,00	-0,26	-0,15	-0,22	0,09	-0,25	0,03	-0,11	-0,25	0,13	-0,22	0,16	0,22	-0,24	-0,24	-0,24	-0,26	-0,24	-0,16	-0,01	-0,25	-0,24	-0,25	-0,24	-0,27
Sum_af_pp_top_n_cits	0,30	0,41	0,61	0,69	0,63	0,02	0,51	0,45	0,30	-0,34	0,40	0,64	0,44	0,63	0,64	0,71	0,69	0,67	-0,26	1,00	0,57	0,51	0,04	0,54	0,29	0,62	0,13	0,36	0,66	0,41	0,17	0,68	0,71	0,71	0,73	0,69	-0,04	0,55	0,74	0,71	0,69	0,71	0,70
Sum_pp_top_prop	0,23	0,28	0,52	0,62	0,56	0,04	0,51	0,49	0,33	-0,32	0,33	0,62	0,40	0,63	0,62	0,59	0,62	0,63	-0,15	0,57	1,00	0,32	0,00	0,39	0,40	0,54	0,25	0,27	0,63	0,46	0,14	0,55	0,57	0,57	0,63	0,64	0,06	0,55	0,59	0,61	0,62	0,57	0,66
average_mjs_mcs	0,33	0,39	0,55	0,55	0,44	-0,08	0,38	0,33	0,18	-0,37	0,44	0,48	0,38	0,46	0,48	0,57	0,55	0,53	-0,22	0,51	0,32	1,00	0,29	0,82	0,42	0,50	0,20	0,26	0,54	0,31	0,27	0,55	0,56	0,56	0,57	0,55	0,09	0,42	0,57	0,56	0,55	0,56	0,54
Min_af_mjs_mcs	-0,03	0,11	0,18	0,06	-0,04	-0,25	-0,08	-0,11	-0,21	-0,25	0,17	0,08	0,20	0,07	0,08	0,08	0,06	0,05	0,09	0,04	0,00	0,29	1,00	0,16	0,27	0,11	-0,04	0,12	0,06	0,12	0,27	0,09	0,08	0,08	0,06	0,06	-0,04	0,09	0,09	0,06	0,06	0,08	0,05
Maks_af_mjs_mcs	0,39	0,41	0,56	0,64	0,54	0,01	0,49	0,44	0,27	-0,37	0,47	0,55	0,37	0,52	0,55	0,63	0,64	0,61	-0,25	0,54	0,39	0,82	0,16	1,00	0,39	0,54	0,24	0,27	0,62	0,34	0,23	0,61	0,61	0,61	0,64	0,63	0,12	0,47	0,62	0,64	0,61	0,62	
Gennemsnt_af_Mnjs	0,08	0,16	0,36	0,35	0,28	-0,06	0,22	0,21	0,09	-0,31	0,25	0,37	0,33	0,38	0,37	0,35	0,35	0,35	0,03	0,29	0,40	0,42	0,27	0,39	1,00	0,29	0,34	0,09	0,35	0,34	0,25	0,32	0,32	0,32	0,35	0,34	0,00	0,36	0,33	0,33	0,35	0,32	0,34
IQP	0,20	0,47	0,88	0,77	0,66	0,08	0,46	0,40	0,18	-0,59	0,51	0,85	0,70	0,80	0,85	0,81	0,77	0,73	-0,11	0,62	0,54	0,50	0,11	0,54	0,29	1,00	-0,08	0,65	0,74	0,64	0,40	0,77	0,79	0,79	0,79	0,76	0,04	0,77	0,77	0,79	0,77	0,79	0,75
nproductivity_adjusted_papers	0,45	-0,02	-0,07	0,22	0,20	0,03	0,49	0,51	0,53	0,19	0,05	0,05	-0,29	0,08	0,05	0,13	0,22	0,25	-0,25	0,13	0,25	0,20	-0,04	0,24	0,34	-0,08	1,00	-0,53	0,25	-0,14	-0,37	0,11	0,12	0,12	0,19	0,21	0,12	-0,05	0,13	0,18	0,22	0,12	0,22
times_cited_more_frequently_than_average_paper_	-0,08	0,36	0,61	0,42	0,37	0,04	0,14	0,09	-0,08	-0,57	0,35	0,55	0,75	0,52	0,55	0,48	0,42	0,39	0,13	0,36	0,27	0,26	0,12	0,27	0,09	0,65	-0,53	1,00	0,42	0,63	0,53	0,47	0,47	0,47	0,43	0,41	-0,02	0,60	0,45	0,44	0,42	0,47	
h	0,40	0,44	0,70	0,88	0,80	0,17	0,69	0,63	0,38	-0,51	0,55	0,78	0,50	0,76	0,78	0,78	0,88	0,87	-0,22	0,66	0,63	0,54	0,06	0,62	0,35	0,74	0,25	0,42	1,00	0,59	0,33	0,72	0,74	0,74	0,86	0,91	0,08	0,64	0,74	0,86	0,88	0,74	0,86
m_quotient	-0,10	0,36	0,60	0,51	0,51	0,14	0,30	0,25	0,07	-0,57	0,30	0,69	0,74	0,67	0,69	0,52	0,51	0,49	-0,16	0,41	0,46	0,31	0,12	0,34	0,34	0,64	-0,14	0,63	0,59	1,00	0,47	0,47	0,48	0,48	0,51	0,52	-0,04	0,72	0,48	0,51	0,51	0,48	0,52



## Appendix 6: Correlation matrix *Public Health*

Indicator	Pys	App	Cpp	Cites	Sum_of_self_cites	percent_sc	P	fp	mC	percent_nc	Cage	AWCR_C	AWCR_pp	AWCR_au	AW_	Min_nCites	Maks_af_n_cits	Sig	Fc	PI	Sum_af_pp_top_n_cits	Sum_pp_top_prop	average_mjs_mcs	Min_af_mjs_mcs	Maks_af_mjs_mcs	Gennemsnit_af_Mnjs	IQP	nproductivity_adjusted_papers	times_cited_more_frequently_than_average_paper_	millers_h	h	m_quotient	h_norm	m_	A_	R_	g	hg_	mg_quotient	e	Q2	h2	AR	Pop_h		
Pys	1,00	0,10	0,39	0,50	0,45	-0,18	0,48	0,47	0,34	-0,22	0,65	0,26	-0,20	0,26	0,26	-0,04	0,43	0,43	0,51	-0,60	0,51	0,28	0,49	-0,05	0,48	-0,01	0,38	0,48	-0,22	0,50	0,50	-0,06	0,46	0,49	0,50	0,43	0,43	0,50	0,50	-0,06	0,46	0,49	0,50	0,43	0,51	
App	0,10	1,00	0,26	0,28	0,29	0,01	0,25	0,02	0,26	-0,03	0,06	0,30	0,17	0,11	0,30	-0,06	0,30	0,30	0,13	-0,02	0,27	0,28	0,23	0,11	0,25	0,18	0,28	0,20	0,16	0,28	0,27	0,26	-0,11	0,27	0,31	0,31	0,29	0,28	0,28	0,29	0,28	0,28	0,31	0,11		
Cpp	0,39	0,26	1,00	0,64	0,55	-0,24	0,40	0,34	0,21	-0,32	0,48	0,60	0,43	0,55	0,60	0,00	0,70	0,70	0,61	-0,37	0,63	0,56	0,65	0,12	0,59	0,33	0,89	0,25	0,33	0,64	0,59	0,32	0,09	0,74	0,77	0,77	0,68	0,63	0,43	0,75	0,68	0,64	0,77	0,63		
Cites	0,50	0,28	0,64	1,00	0,83	-0,14	0,76	0,64	0,51	-0,28	0,50	0,77	0,21	0,71	0,77	-0,08	0,77	0,77	0,83	-0,40	0,89	0,70	0,58	-0,03	0,66	0,22	0,73	0,55	0,14	1,00	0,89	0,43	-0,24	0,76	0,79	0,79	0,97	0,94	0,45	0,86	0,90	1,00	0,79	0,80		
Sum_of_self_cites	0,45	0,29	0,55	0,83	1,00	0,04	0,77	0,64	0,51	-0,30	0,45	0,74	0,18	0,68	0,74	-0,08	0,65	0,65	0,75	-0,33	0,79	0,64	0,49	-0,03	0,57	0,20	0,64	0,56	0,12	0,83	0,85	0,48	-0,26	0,67	0,67	0,67	0,82	0,84	0,46	0,73	0,79	0,83	0,67	0,74		
percent_sc	-0,18	0,01	-0,24	-0,14	0,04	1,00	-0,03	-0,04	-0,05	-0,06	-0,17	-0,09	-0,11	-0,10	-0,09	-0,01	-0,23	-0,23	-0,14	0,25	-0,15	-0,15	-0,26	-0,03	-0,22	-0,11	-0,21	-0,02	-0,07	-0,14	-0,07	0,07	-0,06	-0,21	-0,24	-0,24	-0,16	-0,11	-0,04	-0,20	-0,14	-0,14	-0,24	-0,14		
P	0,48	0,25	0,40	0,76	0,77	-0,03	1,00	0,76	0,68	-0,20	0,39	0,65	0,02	0,61	0,65	-0,12	0,58	0,58	0,71	-0,33	0,75	0,60	0,41	-0,13	0,54	0,11	0,49	0,71	-0,02	0,76	0,81	0,42	-0,45	0,57	0,57	0,57	0,74	0,77	0,38	0,63	0,70	0,76	0,57	0,69		
fp	0,47	0,02	0,34	0,64	0,64	-0,04	0,76	1,00	0,57	-0,22	0,41	0,52	-0,04	0,60	0,52	-0,09	0,49	0,49	0,72	-0,34	0,63	0,51	0,35	-0,18	0,47	0,04	0,42	0,64	-0,08	0,64	0,68	0,33	-0,42	0,50	0,48	0,48	0,62	0,65	0,28	0,53	0,60	0,64	0,48	0,70		
nnC	0,34	0,26	0,21	0,51	0,51	-0,05	0,68	0,57	1,00	0,15	0,14	0,45	-0,08	0,41	0,45	-0,18	0,44	0,44	0,46	-0,18	0,50	0,44	0,28	-0,18	0,40	0,06	0,29	0,62	-0,10	0,51	0,54	0,32	-0,54	0,39	0,41	0,41	0,50	0,52	0,28	0,45	0,48	0,51	0,41	0,45		
percent_nc	-0,22	-0,03	-0,32	-0,28	-0,30	-0,06	-0,20	-0,22	0,15	1,00	-0,46	-0,26	-0,18	-0,27	-0,26	-0,17	-0,20	-0,20	-0,31	0,20	-0,29	-0,21	-0,20	-0,06	-0,18	-0,06	-0,32	-0,09	-0,17	-0,28	-0,30	-0,18	-0,14	-0,24	-0,23	-0,23	-0,28	-0,29	-0,17	-0,26	-0,28	-0,28	-0,23	-0,32		
Cage	0,65	0,06	0,48	0,50	0,45	-0,17	0,39	0,41	0,14	-0,46	1,00	0,33	0,33	0,33	0,33	0,06	0,42	0,42	0,53	-0,61	0,50	0,29	0,53	0,04	0,45	0,05	0,46	0,31	-0,01	0,50	0,49	0,03	0,02	0,46	0,44	0,44	0,50	0,49	0,05	0,47	0,51	0,50	0,44	0,55		
AWCR_C	0,26	0,30	0,60	0,77	0,74	-0,09	0,65	0,52	0,45	-0,26	0,33	1,00	0,38	0,81	1,00	-0,09	0,71	0,71	0,70	-0,25	0,73	0,75	0,47	-0,01	0,55	0,30	0,71	0,43	0,29	0,77	0,74	0,63	-0,22	0,69	0,73	0,73	0,78	0,76	0,68	0,75	0,77	0,73	0,69			
AWCR_pp	-0,20	0,17	0,43	0,21	0,18	-0,11	0,02	-0,04	-0,08	-0,18	0,00	0,38	1,00	0,35	0,38	0,06	0,29	0,29	0,18	0,06	0,19	0,33	0,20	0,18	0,16	0,38	0,42	-0,16	0,74	0,21	0,16	0,45	0,28	0,31	0,33	0,33	0,23	0,20	0,59	0,29	0,23	0,21	0,33	0,20		
AWCR_au	-0,26	0,11	0,55	0,71	0,68	-0,10	0,61	0,60	0,41	-0,17	0,33	0,81	0,35	1,00	0,81	-0,07	0,64	0,64	0,75	-0,25	0,68	0,69	0,42	-0,05	0,51	0,28	0,64	0,41	0,26	0,71	0,69	0,59	-0,20	0,63	0,65	0,65	0,71	0,70	0,62	0,69	0,69	0,71	0,65	0,75		
AW_	0,26	0,30	0,60	0,77	0,74	-0,09	0,65	0,52	0,45	-0,26	0,33	1,00	0,38	0,81	1,00	-0,09	0,71	0,71	0,70	-0,25	0,73	0,75	0,47	-0,01	0,55	0,30	0,71	0,43	0,29	0,77	0,74	0,63	-0,22	0,69	0,73	0,73	0,78	0,76	0,68	0,76	0,75	0,77	0,73	0,69		
Min_nCites	-0,04	-0,06	0,00	-0,08	-0,08	-0,01	-0,12	-0,09	-0,18	-0,17	0,06	-0,09	0,06	-0,07	-0,09	1,00	-0,08	1,00	-0,08	-0,08	-0,05	-0,01	-0,07	-0,08	-0,02	0,01	-0,07	0,01	-0,04	-0,12	0,06	-0,08	-0,08	-0,06	0,16	-0,06	-0,07	-0,07	-0,08	-0,08	-0,05	-0,07	-0,07	-0,08	-0,07	-0,03
Maks_af_n_cits	0,43	0,30	0,70	0,77	0,65	-0,23	0,58	0,49	0,44	-0,20	0,42	0,71	0,29	0,64	0,71	-0,08	1,00	1,00	0,68	-0,38	0,70	0,63	0,59	0,00	0,64	0,25	0,76	0,40	0,23	0,77	0,68	0,38	-0,16	0,71	0,87	0,87	0,80	0,73	0,48	0,86	0,73	0,77	0,87	0,66		
Sig	0,43	0,30	0,70	0,77	0,65	-0,23	0,58	0,49	0,44	-0,20	0,42	0,71	0,29	0,64	0,71	-0,08	1,00	1,00	0,68	-0,38	0,70	0,63	0,59	0,00	0,64	0,25	0,76	0,40	0,23	0,77	0,68	0,38	-0,16	0,71	0,87	0,87	0,80	0,73	0,48	0,86	0,73	0,77	0,87	0,66		
Fc	0,51	0,13	0,61	0,83	0,75	-0,14	0,71	0,72	0,46	-0,31	0,53	0,70	0,18	0,75	0,70	-0,05	0,68	0,68	1,00	-0,42	0,81	0,66	0,54	-0,06	0,60	0,20	0,68	0,53	0,10	0,83	0,81	0,39	-0,21	0,72	0,71	0,71	0,82	0,82	0,41	0,76	0,81	0,83	0,71	0,88		
PI	-0,60	-0,02	-0,37	-0,40	-0,33	0,25	-0,33	-0,34	-0,18	0,20	-0,61	-0,25	0,06	-0,25	-0,25	-0,01	-0,38	-0,38	-0,42	1,00	-0,41	-0,25	-0,49	0,01	-0,42	-0,01	-0,36	-0,30	0,08	-0,40	-0,37	0,04	0,09	-0,37	-0,38	-0,38	-0,41	-0,39	0,00	-0,40	-0,40	-0,40	-0,38	-0,43		
Sum_af_pp_top_n_cits	0,51	0,27	0,63	0,89	0,79	-0,15	0,75	0,63	0,50	-0,29	0,50	0,73	0,19	0,68	0,73	-0,07	0,70	0,70	0,81	-0,41	1,00	0,70	0,58	-0,03	0,64	0,23	0,71	0,57	0,10	0,89	0,90	0,43	-0,24	0,77	0,74	0,74	0,89	0,91	0,43	0,80	0,89	0,89	0,74	0,82		
Sum_pp_top_prop	0,28	0,28	0,56	0,70	0,64	-0,15	0,60	0,51	0,44	-0,21	0,29	0,75	0,33	0,69	0,75	-0,08	0,63	0,63	0,66	-0,25	0,70	1,00	0,43	-0,04	0,51	0,32	0,64	0,44	0,22	0,70	0,68	0,54	-0,20	0,66	0,66	0,66	0,71	0,70	0,57	0,68	0,70	0,70	0,66	0,66		
average_mjs_mcs	0,49	0,23	0,65	0,58	0,49	-0,26	0,41	0,35	0,28	-0,20	0,53	0,47	0,20	0,42	0,47	-0,02	0,59	0,59	0,54	-0,49	0,58	0,43	1,00	0,14	0,73	0,34	0,62	0,38	0,07	0,58	0,55	0,19	0,00	0,59	0,63	0,63	0,61	0,58	0,25	0,63	0,59	0,58	0,63	0,56		
Min_af_mjs_mcs	-0,05	0,11	0,12	-0,03	-0,03	-0,03	-0,13	-0,18	-0,18	-0,06	0,04	-0,01	0,18	-0,05	-0,01	0,01	0,00	0,00	-0,06	0,01	-0,03	-0,04	0,14	1,00	0,00	0,22	0,07	-0,11	-0,11	-0,03	-0,05	0,00	0,29	0,00	0,03	0,03	-0,01	-0,03	0,03	0,01	-0,02	-0,03	0,03	-0,05		
Maks_af_mjs_mcs	0,48	0,25	0,59	0,66	0,57	-0,22	0,54	0,47	0,40	-0,18	0,45	0,55	0,16	0,51	0,55	-0,07	0,64	0,64	0,60	-0,42	0,64	0,51	0,73	0,00	1,00	0,28	0,61	0,48	0,06	0,66	0,63	0,27	-0,15	0,60	0,65	0,65	0,67	0,65	0,32	0,66	0,64	0,66	0,65	0,61		
Gennemsnit_af_Mnjs	-0,01	0,18	0,33	0,22	0,20	-0,11	0,11	0,04	0,06	-0,06	0,05	0,30	0,38	0,28	0,30	0,01	0,25	0,25	0,20	-0,01	0,23	0,32	0,34	0,22	0,28	1,00	0,31	0,16	0,12	0,22	0,21	0,29	0,16	0,27	0,28	0,28	0,24	0,22	0,33	0,27	0,24	0,22	0,28	0,23		
IQP	0,38	0,28	0,89	0,73	0,64	-0,21	0,49	0,42	0,29	-0,32	0,46	0,71	0,42	0,64	0,71	-0,04	0,76	0,76	0,68	-0,36	0,71	0,64	0,62	0,07	0,61	0,31	1,00	0,31	0,34	0,73	0,67	0,41	0,00	0,79	0,84	0,84	0,77	0,72	0,50	0,82	0,76	0,73	0,84	0,69		
nproductivity_adjusted_papers	0,48	0,20	0,25	0,55	0,56	-0,02	0,71	0,64	0,62	-0,09	0,31	0,43	-0,16	0,41	0,43	-0,12	0,40	0,40	0,53	-0,30	0,57	0,44	0,38	-0,11	0,48	0,16	0,31	1,00	-0,28	0,55	0,61	0,25	-0,50	0,39	0,39	0,39	0,53	0,57	0,18	0,44	0,51	0,55	0,39	0,52		
times_cited_more_frequently_t	-0,22	0,16	0,33	0,14	0,12	-0,07	-0,02	-0,08	-0,10	-0,17	-0,01	0,29	0,74	0,26	0,29	0,06	0,23	0,23	0,10	0,08	0,10	0,22	0,07	0,11	0,06	0,12	0,34	-0,28	1,00	0,14	0,09	0,37	0,25	0,24	0,25	0,25	0,16	0,12	0,50	0,22	0,16	0,14	0,25	0,12		
millers_h	0,50	0,28	0,64	1,00	0,83	-0,14	0,																																							

